# KENTUCKY AMBIENT/WATERSHED WATER QUALITY MONITORING STANDARD OPERATING PROCEDURE MANUAL

**Environmental and**
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**Division of Water**
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# Kentucky Ambient/Watershed Water Quality Monitoring Standard Operating Procedure Manual 2005

**Kentucky Department for Environmental Protection**
**Division of Water**
**Water Quality Branch**

**This report has been approved for release:**

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**Date**

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# KENTUCKY AMBIENT/ WATERSHED WATER QUALITY MONITORING STANDARD OPERATING PROCEDURE MANUAL

## I. INTRODUCTION

Critical to securing legally defensible water quality data is the implementation of a rigorous QA/QC program. Addressing the needs and objectives of a monitoring study/program is the initial step to assure the success and utility of the program and data. However, without documentation and adherence to standard operating procedures, the information generated is of questionable value. Since the collection of the water sample and associated field measurements are such a vital step in the information system, this manual documents the operational procedures and quality assurance for the Kentucky Ambient/Watershed Monitoring Assessment program.

The Kentucky Ambient/Watershed Monitoring Assessment program is designed to assess the status and trends in the quality of Kentucky's surface water resources and to develop an understanding of the major factors that affect water-quality conditions and use attainment. The Kentucky Ambient/Watershed Monitoring Assessment program consists of three components. These include the Ambient Monitoring Assessment, the Watershed Monitoring Assessment and the Lake Monitoring Assessment. The goals of the Ambient Monitoring Assessment are to characterize background conditions of water quality variables, assess use attainment and determine long-term trends in rivers and streams across Kentucky. The goals of the Watershed Monitoring Assessment are to characterize water-quality variable conditions and assess use attainment over an intensively sampled one-year period. The goals of the Lake Monitoring Assessment are to determine the trophic status, use support and long-term trends in water quality.

Much of the guidance for developing this Standard Operating Procedure Manual came from U.S. Geological Survey National Field Manual (http://water.usgs.gov/owq/FieldManual/). This national field manual presents the rationale and operating procedures for water collection activities conducted by the USGS.

# II. PLANNING

Before water quality sampling can be conducted, information about sampling locations, sampling variables and methods is needed. Sampling cannot begin until a plan has been developed that specifies the locations, number of samples, variables to be sampled, numbers and kinds of QA/QC samples and desired quality of the data. Samplers are responsible for collecting and handling samples and keeping records in accord with the sampling plan.

**Health and Safety**

Before attempting any water quality sampling, one must be aware of the applicable health and safety requirements. Because sample collection often is done at contaminated sites or far from immediate medical attention, it is important to follow all safety requirements and guidelines (STEP 7). In addition, since sampling is often conducted at highway bridge crossings, it is important to develop a highway safety plan for each site. Appendix A presents a model safety plan for bridge crossing sampling sites.

## Step 1. Selection of Potential Water Quality Sampling Stations

A water quality station is a specific location on a water body from which a sample is collected. Its location is critical to the success of the monitoring program. Ideally, location of river monitoring stations should incorporate the following characteristics:

1. safety of samplers;
2. accessibility;
3. proximity to a current hydrological recording station;
4. transport time to laboratories;
5. conformation of stream reach sampled (straight channels are preferred); and
6. reach mixing; sites upstream or downstream of major tributaries or point sources should be avoided to minimize problems caused by backwater effects or poorly mixed flows.

If possible, a reconnaissance visit should be made to each site prior to sample collection. If the river is flowing, measurement of temperature, pH, specific conductance and dissolved oxygen at intervals across a transect and at depths will indicate the degree of mixing at the site. The variability in these field measurements will aid in the decision to sample a given location.

The Water Quality Branch selects water quality monitoring locations for the Ambient Monitoring Assessment program. Ambient Monitoring Assessment locations, which monitor long-term river conditions, are located within hydrologic units using the approach of Ward and others (op. cit.). The ambient network was expanded to 70 stations in 1998 with the initiation of the watershed initiative. This increase was made possible by decreasing sampling from monthly to bimonthly. Table 1 provides a list of the ambient network stations.

Table 1. Kentucky primary water quality monitoring stations.

| Major River Basin | Station | Hydro Unit | Mile-Point | Location | Latitude | Longitude | Latitude | Longitude | Drainage Area (mi2) | **Type** |
|---|---|---|---|---|---|---|---|---|---|---|
| Big Sandy | | | | | | | | | | |
| Tug Fork | 2 | 05070201 | 35.1 | at Kermit, WV | 37 50 16 | 82 24 35 | 37.83778 | -82.40972 | 1280 | hydrologic unit index site |
| Tug Fork | 3 | 05070201 | 77.7 | at Freeburn | 37 33 58 | 82 08 38 | 37.56611 | -82.14389 | 271 | mid-hydrologic unit index |
| Levisa Fork | 6 | 05070202 | 114.6 | nr Pikeville | 37 27 51 | 82 31 33 | 37.46417 | -82.52583 | 1232 | hydrologic unit index site |
| Levisa Fork | 64 | 05070203 | 29.6 | nr Louisa | 38 04 50 | 82 36 01 | 38.08056 | -82.60028 | 2326 | hydrologic unit index site |
| Levisa Fork | 94 | 05070203 | 75 | at Auxier | 37 43 44.2 | 82 45 16.1 | 37.72894 | -82.75447 | 1726 | mid-hydrologic unit index |
| Beaver Creek | 95 | 05070203 | 1 | Allen | 37 36 09.6 | 82 43 39.4 | 37.60267 | -82.72761 | 240 | major tributary |
| Johns Creek | 96 | 05070203 | 26.6 | at McCombs | 37 39 19.1 | 82 31 33.2 | 37.65531 | -82.52589 | 168 | inflow to Dewey Lake;ma |
| Little Sandy | | | | | | | | | | |
| Little Sandy River | 49 | 05090104 | 13.2 | Argillite | 38 29 26 | 82 50 03 | 38.49056 | -82.83417 | 522 | hydrologic unit index site |
| Tygarts Creek | | | | | | | | | | |
| Tygarts Creek | 111 | 05090103 | 23.5 | nr Lynn | 38 35 58.9 | 82 57 10.1 | 38.59969 | -82.95281 | 242 | hydrologic unit index site |
| Ohio River Tributaries | | | | | | | | | | |
| Kinniconick Creek | 63 | 05090201 | 10.4 | nr Garrison | 38 34 28.6 | 83 11 17.0 | 38.57461 | -83.18806 | 175 | major tributary |
| Licking River | | | | | | | | | | |
| Licking River | 62 | 05100101 | 226.4 | at West Liberty | 37 54 53 | 83 15 43 | 37.91472 | -83.26194 | 335 | inflow to Cave Run Lake |
| Slate Creek | 93 | 05100101 | 10 | nr Owingsville | 38 08 29.3 | 83 43 43.0 | 38.14147 | -83.72861 | 230 | major tributary |
| Licking River | 61 | 05100101 | 78.2 | at Claysville | 38 31 14 | 84 11 00 | 38.52056 | -84.18333 | 1993 | mid-hydrologic unit index |
| Licking River | 112 | 05100101 | 56.3 | at Butler | 37 47 22.9 | 84 22 03.0 | 37.78969 | -84.36750 | 3385 | hydrologic unit index site |
| North Fork Licking River | 60 | 05100101 | 6.9 | nr Milford | 38 35 50 | 84 09 20 | 38.59722 | -84.15556 | 290 | major tributary |

Table 1 (cont.). Kentucky primary water quality monitoring stations.

| Major River Basin | Station | Hydro Unit | Mile-Point | Location | Latitude | Longitude | Latitude | Longitude | Drainage Area (mi2) | **Type** |
|---|---|---|---|---|---|---|---|---|---|---|
| Licking River (cont.) | | | | | | | | | | |
| Stoner Creek | 101 | 05100102 | 0.6 | nr Ruddles Mill | 38 18 10.3 | 84 14 58.9 | 38.30286 | -84.24969 | 284 | major tributary |
| Salt River | | | | | | | | | | |
| Salt River | 29 | 05140102 | 22.9 | at Shepardsville | 37 59 06 | 85 43 03 | 37.98500 | -85.71750 | 1197 | hydrologic unit index site |
| Salt River | 52 | 05140102 | 82.5 | at Glensboro | 38 00 08 | 85 03 35 | 38.00222 | -85.05972 | 172 | major reservoir inflow |
| Brashears Creek | 105 | 05140102 | 1.2 | at Taylorsville | 38 02 14 | 85 20 26 | 38.03722 | -85.34056 | 262 | major tributary |
| Floyds Fork | 100 | 05140102 | 7.4 | nr Shepardsville | 38 02 06 | 85 39 34 | 38.03500 | -85.65944 | 259 | major tributary |
| Rolling Fork | 57 | 05140103 | 12.3 | nr Lebanon Jct | 37 49 23 | 85 44 53 | 37.82306 | -85.74806 | 1375 | hydrologic unit index site |
| Beech Fork | 41 | 05140103 | 48.0 | nr Maud | 37 49 58 | 85 17 46 | 37.83278 | -85.29611 | 436 | major tributary |
| Kentucky River | | | | | | | | | | |
| Eagle Creek | 22 | 05100205 | 21.5 | Glencoe | 38 42 22 | 84 49 32 | 38.70611 | -84.82556 | 437 | hydrologic unit index site |
| Kentucky River | 24 | 05100205 | 64.8 | Frankfort | 38 12 46.3 | 84 52 21.5 | 38.21286 | -84.87264 | 5412 | hydrologic unit index site |
| Kentucky River | 66 | 05100205 | 30.5 | Lockport | 38 26 42 | 84 57 25 | 38.44500 | -84.95694 | 6180 | hydrologic unit index site |
| Kentucky River | 67 | 05100205 | 118.8 | High Bridge | 37 49 08.9 | 84 42 23.3 | 37.81914 | -84.70647 | 5036 | hydrologic unit index site |
| Elkhorn Creek | 98 | 05100205 | 10.3 | Peaks Mill | 38 16 06.9 | 84 48 52.3 | 38.26858 | -84.81453 | 473 | major trib |
| Dix River | 45 | 05100205 | 34.7 | nr Danville | 37 38 30 | 84 39 39 | 37.64167 | -84.66083 | 318 | hydrologic unit index site |
| Silver Creek | 99 | 05100205 | 5.9 | Ruthion | 37 43 58 | 84 26 13.2 | 37.73278 | -84.43700 | 100 | major trib |
| Kentucky River | 58 | 05100204 | 191.2 | nr Trapp | 37 50 48 | 84 04 52 | 37.84667 | -84.08111 | 3236 | hydrologic unit index site |
| Red River | 46 | 05100204 | 21.6 | Clay City | 37 51 55 | 83 56 00 | 37.86528 | -83.93333 | 362 | hydrologic unit index site |
| North Fork Kentucky River | 31 | 05100201 | 49.7 | Jackson | 37 33 04 | 83 23 04 | 37.55111 | -83.38444 | 1101 | hydrologic unit index site |
| Troublesome Creek | 90 | 05100201 | 7.2 | nr Clayhole | 37 28 01.7 | 83 16 46.2 | 37.46714 | -83.27950 | 187 | major trib |
| Middle Fork Kentucky River | 32 | 05100202 | 8.4 | Tallega | 37 33 18 | 83 35 38 | 37.55500 | -83.59389 | 537 | hydrologic unit index site |

Table 1 (cont.). Kentucky primary water quality monitoring stations.

| Major River Basin | Station | Hydro Unit | Mile-Point | Location | Latitude | Longitude | Latitude | Longitude | Drainage Area (mi2) | Type |
|---|---|---|---|---|---|---|---|---|---|---|
| Kentucky River (cont.) | | | | | | | | | | |
| South Fork Kentucky River | 33 | 05100203 | 12.1 | Booneville | 37 28 30 | 83 40 14 | 37.47500 | -83.67056 | 722 | hydrologic unit index site |
| Red Bird River | 91 | 05100203 | 50.4 | nr Oneida | 37 14 12.6 | 83 38 42.5 | 37.23683 | -83.64514 | 190 | major trib |
| Goose Creek | 92 | 05100203 | 3.4 | nr Oneida | 37 14 13.3 | 83 40 15.6 | 37.23703 | -83.67100 | 250 | major trib |
| Cumberland River | | | | | | | | | | |
| Cumberland River | 86 | 05130101 | 661 | at Calvin | 36 43 19.7 | 83 37 31.9 | 36.72214 | -83.62553 | 770 | mid-hydrologic unit index |
| Cumberland River | 9 | 05130101 | 562.6 | at Cumberland Falls | 36 50 08 | 84 20 25 | 36.83556 | -84.34028 | 1977 | hydrologic unit index site |
| Clear Fork | 87 | 05130101 | 0.9 | nr Williamsburg | 36 43 33.2 | 84 08 32.6 | 36.72589 | -84.14239 | 370 | major tributary |
| Rockcastle River | 10 | 05130102 | 24.7 | at Billows | 37 10 17 | 84 17 48 | 37.17139 | -84.29667 | 604 | hydrologic unit index site |
| Horse Lick Creek | 51 | 05130102 | 0.1 | nr Lamero | 37 19 13.3 | 84 08 19.2 | 37.32036 | -84.13867 | 62 | outstanding state resource |
| Cumberland River | 7 | 05130103 | 422.7 | nr Burkesville | 36 44 46.5 | 85 22 18.2 | 36.74625 | -85.37172 | 6053 | hydrologic unit index site |
| Buck Creek | 88 | 05130103 | 12.3 | nr Dykes | 37 03 36.3 | 84 25 34.9 | 37.06008 | -84.42636 | 294 | major tributary |
| South Fork Cumberland R | 8 | 05130104 | 44.8 | at Blue Heron | 36 40 13 | 84 32 56 | 36.67028 | -84.54889 | 954 | hydrologic unit index site |
| Little River | 43 | 05130205 | 24.4 | nr Cadiz | 36 50 26 | 87 46 39 | 36.84056 | -87.77750 | 269 | major tributary |
| Red River | 69 | 05130205 | 49 | nr Keysburg | 36 38 26.9 | 86 58 44.7 | 36.64081 | -86.97908 | 509 | hydrologic unit index site |
| Green River | | | | | | | | | | |
| Green River | 18 | 05110001 | 226 | at Munfordville | 37 16 07.2 | 85 53 07.0 | 37.26867 | -85.88528 | 1673 | hydrologic unit index site |
| Green River | 76 | 05110001 | 334.2 | nr Neatsville | 37 11 30.9 | 85 07 49.1 | 37.19192 | -85.13031 | 339 | major reservoir inflow |
| Nolin River | 21 | 05110001 | 80.9 | at White Mills | 37 33 18 | 86 01 52 | 37.55500 | -86.03111 | 357 | major reservoir inflow; m |
| Russell Creek | 77 | 05110001 | 10 | nr Bramlett | 37 10 04.1 | 85 28 12.6 | 37.16781 | -85.47017 | 289 | major tributary |
| Little Barren River | 78 | 05110001 | 6.3 | nr Monroe | 37 13 35.2 | 85 40 39.2 | 37.22644 | -85.67756 | 256 | major tributary |
| Bear Creek | 75 | 05110001 | 11.8 | nr Huff | 37 14 55.8 | 86 21 40.4 | 37.24883 | -86.36122 | 159 | major tributary |
| Barren River | 72 | 05110002 | 1 | Woodbury | 37 10 23.8 | 86 37 23.5 | 37.17328 | -86.62319 | 1968 | hydrologic unit index site |

Table 1 (cont.). Kentucky primary water quality monitoring stations.

| Major River Basin | Station | Hydro Unit | Mile-Point | Location | Latitude | Longitude | Latitude | Longitude | Drainage Area (mi2) | Type |
|---|---|---|---|---|---|---|---|---|---|---|
| Green River ( Cont.) | | | | | | | | | | |
| Barren River | 73 | 05110002 | 113.8 | nr Holland | 36 41 46.8 | 86 02 48.2 | 36.69633 | -86.04672 | 398 | major reservoir inflow |
| Drakes Creek | 74 | 05110002 | 8 | nr Bowling Green | 36 56 05.7 | 86 23 34.7 | 36.93492 | -86.39297 | 502 | major tributary |
| Green River | 55 | 05110003 | 72 | at Livermore | 37 29 03.1 | 87 08 04.0 | 37.48419 | -87.13444 | 6431 | hydrologic unit index site |
| Mud River | 56 | 05110003 | 17.4 | nr Gus | 37 07 24 | 86 54 02 | 37.12333 | -86.90056 | 268 | major tributary |
| Green River | 103 | 05110003 | 150 | nr Woodbury | 37 11 00.4 | 86.36.57.5 | 37.18344 | -86.61597 | 3140 | hydrologic unit index site |
| Rough River | 14 | 05110004 | 62.5 | nr Dundee | 37 33 46 | 86 46 15 | 37.56278 | -86.77083 | 757 | mid-hydrologic unit index |
| Rough River | 54 | 05110004 | 1 | nr Livermore | 37 29 03.1 | 87 07 07.6 | 37.48419 | -87.11878 | 1068 | hydrologic unit index site |
| Panther Creek | 70 | 05110005 | 5.4 | nr Sorgho | 37 43 38.3 | 87 16 50.5 | 37.72731 | -87.28069 | 374 | major tributary |
| Pond River | 12 | 05110006 | 12.4 | nr Sacramento | 37 23 42 | 87 21 11.2 | 37.39500 | -87.35311 | 523 | hydrologic unit index site |
| Ohio River Tributaries | | | | | | | | | | |
| Highland Creek | 110 | 05140102 | 13.4 | nr Smith Mills | 37 45 24.8 | 87 47 42.0 | 37.75689 | -87.79500 | 390 | major tributary |
| Tradewater River | | | | | | | | | | |
| Tradewater River | 112 | 05140205 | 24.9 | nr Piney | 37 23 56.0 | 87 54 16.9 | 37.39889 | -87.90469 | 619 | hydrologic unit index site |
| Tennessee River | | | | | | | | | | |
| Clarks River | 106 | 06040006 | 14.3 | nr Sharpe | 36 58 18.5 | 88 30 53.9 | 36.97181 | -88.51497 | 313 | hydrologic unit index site |
| West Fork Clarks River | 107 | 06040006 | 7.8 | nr Symsonia | 36 55 56.9 | 88 32 37.6 | 36.93247 | -88.54378 | 187 | major trib |
| Mississippi River | | | | | | | | | | |
| Bayou de Chien | 109 | 08010201 | 11.2 | nr Moscow | 36 36 54.8 | 89 01 48.4 | 36.61522 | -89.03011 | 178 | major tributary |
| Mayfield Creek | 42 | 08010201 | 10.8 | nr Magee Springs | 36 55 47.6 | 88 56 34.7 | 36.92989 | -88.94297 | 300 | major tributary |

Watershed Monitoring Assessment locations are generally at the downstream end of 5th order watersheds or near the downstream end of reference reach streams. Watershed Monitoring locations are selected after consultation with the Watershed Coordinator and river basin teams.

Lake Monitoring Assessment sampling sites are dependent on lake size. In small reservoirs and natural lakes one site is usually sufficient. This site is located just up stream of the dam at the deepest point in the lake. In larger reservoirs, additional sites may be located to sample water quality in embayment areas.

## STEP 2. Preparation of a Sample Plan

A sample plan shall be prepared for each sampling location and shall contain the following components:

1. Objective(s)
2. Maps
3. Rationale
4. Requests for Analyses
5. Field Methods and Procedures
6. Health and Safety Plan
7. Data management

Water quality sampling is expensive and time consuming, so be certain before sampling begins that sample will serve project goals. The original sampling plan will be kept by the Water Quality Branch and a copy of the sampling plan will be sent to the Regional Office(s) conducting the sampling.

## STEP 3. Location and Description of the Sampling Locations

The location and identification number of a water quality sampling station (monitoring point) should be accurately marked on a large-scale map as an X, circle or dot. This not only enables field personnel to easily find the stations, but also allows the data to be digitized into a computer database. As part of the station file, the following should be included:

1. Diagram depicting physical setting
2. Coordinates
3. Photographs
4. Driving routes to sampling stations

**Determining Station Coordinates**

Latitude and longitude are the coordinate pairs that are used to define location on a three-dimensional globe. These coordinate pairs are used in various databases to assign location of sampling points. Coordinates are to be read in decimal degrees (XX.XXXX/-XXX.XXXX) as required in Database Recommendations for Location Version 1.0 (Kentucky Natural Resources and Environmental Protection Cabinet, Office of Information Services, no date). Latitude and longitude may be determined using either GPS (global positioning system) receivers, USGS maps or mapping software such as Arc View.

**Photographing the Station**

Photograph fixed-station sites on a regular basis for site documentation purposes. Take enough photos on the first visit to the site to establish a complete photo record of the site and its surroundings. (This also will assist a first-time visitor in locating the site.) After the first visit, take photos according to the procedures outlined below.

Take photos from established and constant photopoints. The preferred photopoint is a naturally occurring object, such as a large tree or boulder. For example, the photographer can put his or her back against a specific tree trunk to take one of the required photographs at each visit to the site. If naturally occurring landmarks are unavailable at a given site, try to mark the photopoint in some durable yet unobtrusive and temporary way, such as with a pile of rocks. At the first visit to the site, describe the photopoints in detail in the field notes. Record field notes in the site files as a permanent part of the file.

Include a person in the photo of the sample point to show scale. For a surface water station, take two photos using a digital camera from: 1) upstream of the sample point looking downstream at the sample point and 2) downstream of the sample point looking upstream at the sample point.

Take additional photos if you notice any significant change in the site area, such as severe channel scour, severe deposition, recent construction or other biological or ecological changes that warrant documentation. Emphasize in the photos those aspects that are likely to impact water quality.

Digital camera photos are to be accompanied by the following information: site ID, site name, date and time and the orientation of the photo. The Ambient Monitoring Coordinator will maintain diskettes on file.

On the last visit to a site, retake the same photos that were taken on the first visit (from the same photopoints) in order to document the changes that occurred over the lifetime of the site.

# III. PREPARATION

## STEP 1. Containers and Preservatives

Sample containers and preservatives can be replenished by e-mailing the Ambient Monitoring Coordinator. Allow one month for supplies to be delivered after sending e-mail. Labels, coolers and ice may be obtained from local vendors through use of a PRO-CARD. Field data sheets will be e-mailed to regional offices as updated. Copies of the field data sheets are to be reproduced at the regional offices. Table 2 lists containers and preservatives needed for analyses to be run on ambient/ watershed samples.

Table 2. Containers and preservatives needed for ambient/watershed Samples

| Container Size, Type | Preservation Method | Variable Groups | Analysis Method(s) | Holding Time |
|---|---|---|---|---|
| 1 liter, HDPE bottle | Cool to 4 degrees C | Bulk variables (TSS, Cl, SO4, Alkalinity, TOC) | EPA 160.2; ASTM (18th) 4500-Cl B; EPA 375.1; EPA 310.1; EPA 415.1 | TSS – 7 da; Alkalinity – 14 da; remainder 28 da |
| 1 liter, HDPE bottle | H2SO4 < pH 2.0, Cool to 4 degrees C | Nutrients (ammonia-N; TKN-N; nitrite+nitrate-N; total phosphorous | EPA 350.1; EPA 351.2; EPA353.2; EPA 365.1 | 28 da |
| 1 liter, HDPE bottle (pre-cleaned) | HNO3 < pH 2.0 | Metals (calcium, iron, magnesium, potassium, sodium – ICP/AES; aluminum, arsenic, barium, cadmium, chromium, copper, lead, manganese, zinc – ICP/MS) | EPA methods 200.7 and 200.8; analysis methods vary by metal | 6 mo |
| 1 liter, amber glass bottle | 5 ml conc. HCL, Cool to 4 degrees C | Low level Mercury | EPA 1631E | 28 da |
| 1 liter, amber glass bottle | Cool to 4 degrees C | N/P Pesticides Method 507 (e.g. atrazine, metribuzin, simazin) | EPA 507 | 7 da |
| 1 liter, amber glass bottle | Cool to 4 degrees C | Pesticides Method 508 [1] (e.g. organochlorine compounds, chlorpyrifos, endosulfan) | EPA 508 | 7 da |
| 1 liter, amber glass bottle | Cool to 4 degrees C | Herbicides Method 515.3 (e.g. 2, 4-D) | EPA 515.3 | 7 da |
| 125 ml, amber glass bottle | Cool to 4 degrees C, 4 ml monochloroacetic acid | Carbamates Method 531.1 | EPA 531.1 | 28 da |
| 125 ml, amber glass bottle | Cool to 4 degrees C | Glyphosate (Roundup) | EPA 547 | 18 months/frozen |
| 120 ml, disposable coliform sample container | Cool to 4 degrees C; samples should arrive at lab within 6 hours (ideally) + 2 hour lab prep time (acceptable) | Fecal coliform bacteria | ASTM (19th) 9222 D | 8 hours maximum |
| Camera film container | Filter through .45 µ Whatman glass fiber filter, cool to 4 degrees C | Chlorophyll-a | ASTM (19th) 10200H | 3 weeks if frozen |

[1] Method 508 pesticides are normally taken from the Method 507 bottle; therefore, do not collect Method 508 samples in a separate bottle unless instructed.

## STEP 2. Assembling and calibrating sampling equipment

Obtaining representative surface water samples commonly requires much (or many pieces of) equipment. Make sure you are prepared. This is especially important if the sampling site is far from the office, making it difficult to replenish supplies or pick up forgotten items. The checklist of supplies in Appendix B is a useful guide for many sampling projects.

### Calibration of Field Meters

Field measurements are the determinations of physical properties or chemical constituents that are measured onsite, as close as possible in time and space to the media being sampled. Measurements of water temperature, pH, DO and specific conductance could change dramatically within a few minutes or hours after sample collection. Therefore, field measurements of these properties are required if representative results of in-stream conditions are to be obtained. Field measurements, field notes on sampling methods or equipment used, site observations and calibration information should be recorded on field forms for later reference. These field forms or notes may vary in format.

## STEP 3. Cleaning Sampling Equipment

Equipment that makes contact with a water quality sample must be carefully cleaned before reuse. Examples are pump tubing, DH-81 samplers and mason jars. The following cleaning procedure has been adopted and modified from the USGS National Field Manual (op. cit.):

1. Wearing powder-free vinyl gloves, wash equipment with nonphosphate detergent.

2. Rinse with tap water to remove all soap residues. Follow with a rinse with deionized water (DIW).

**NOTE:** FOR EQUIPMENT USED EXCLUSIVELY FOR ORGANIC-COMPOUND PROCESSING, OMIT STEPS 3 AND 4.

3. Rinse with 5% hydrochloric acid solution.

4. Change gloves and rinse three times with DIW.

**NOTE:** IF ORGANIC-COMPOUND SAMPLES ARE NOT COLLECTED, OMIT STEPS 5 AND 6.

5. Rinse with minimal amount of pesticide-grade methanol.

6. Allow to air dry.

7. Protect cleaned equipment by placing in a clean ziplock bag for storage and transport.

8. Rinse sampling equipment at the site with native water before sampling.

If several sets of sampling equipment are available, decontamination can be performed in batches at the beginning or end of a sampling day. This saves time and reduces the number of field blanks necessary.

# IV. SAMPLING

## STEP 1. Health and Safety Guidelines

To ensure safety, fieldwork requires an awareness of potential hazards and knowledge of regulations and recommended procedures. The collection of water quality data in the field brings field personnel in touch with numerous hazards. Personnel routinely work in extreme environmental conditions and in remote locations. Winter weather conditions can present an especially hazardous time for water quality sampling. Roads are often icy and wind chills may be low enough to cause skin damage. Therefore, the following are strongly recommended. Do not make sampling trips when either travel advisories have been issued or the wind chill is minus 10 degrees F or lower. Two web sites, the Golden Gate Weather Services' New Wind Chill Temperature Formula (available online at http://www.ggweather.com/windchill.htm) and the Kentucky Transportation Cabinet's KY Direct 511 Traffic & Travel Info (available online at http://www.511.ky.gov/), may be especially useful for assessing winter weather conditions and driving advisories. Water quality studies involve the transportation and use of equipment and chemicals. Personnel routinely come in direct and indirect contact with waterborne and airborne chemicals and pathogens and with potentially dangerous animals and plants. General safety guidelines include:

1. Certification of samplers in first aid, CPR, bloodborne pathogens training and driver training. If an individual will be involved in towing trailers, trailer training is also required.
2. Conducting sampling from a boat requires at least two persons.
3. Determining the location of the nearest hospital, clinic or physician before sampling.
4. Receiving the appropriate immunizations. Vaccinations for tetanus, hepatitis A and B are recommended when working near contaminated waters.
5. Notifying others of your itinerary and whereabouts.
6. Taking precautions against hunters, poisonous snakes and sudden water rise.
7. Carrying identification.
8. Taking a cellular telephone on sampling trips.
9. Being aware of all bridge safety guidelines (Appendix A).

10. Wearing disposable, powderless gloves when handling sample preservations such as acid.

## STEP 2. Field Measurements

Field measurements taken by the Kentucky Ambient/Watershed Monitoring Assessment program are performed using multimeters. Single variable (e.g. dissolved oxygen, specific conductance) meters are still used by a few regional offices. These older meters are being phased out and replaced by multimeters.

Before taking field measurements, sensors must be allowed to equilibrate to the temperature of the water being monitored. Allow at least 60 seconds (or follow the manufacturer guidelines) for sensors to equilibrate with sample water. Sensors have equilibrated adequately when temperature readings have stabilized. Field measurements should be made in-stream if possible (at the centroid of flow) if the stream appears to be completely mixed from bank to bank.

Appendix C presents QA/QC audit procedures for field meters.

### Temperature

Field measurements should include both air temperature and water temperature. Air temperature is defined to be an observation and may be assessed from the air temperature given over the radio. Because of possible environmental contamination if broken, mercury-filled thermometers should not be used. Water temperatures should be determined using a thermistor, an electrical device made of a solid semiconductor that has a high temperature coefficient of resistivity. Thermistor calibration should be checked in the laboratory or office once a year using an American Society for Testing and Materials (ASTM) thermometer. Water temperatures should represent the mean temperature of the stream at the time of the observation. A horizontal and vertical cross-section profile will determine variability, if any. Streams with highly variable temperature profiles should have several readings averaged to use as the mean, and those variations should be documented. Streams with fairly uniform temperatures (less than 2° C variance 95 percent of the time) generally will have one measurement that can be made and reported as the stream temperature. In wadeable streams, stand so that a shadow is cast upon the site for the temperature measurement. Hold the thermistor or probe by its top and immerse it in the water. Allow it to stabilize for at least one minute, then read and record the temperature to the nearest 0.1° C without removing from the water.

When temperature cannot be measured in-stream, it should be measured in a 2-½-gallon bucket. The following conditions must be met when measuring temperature from a bucket.

- The bucket must be large enough to allow full immersion of the thermistor or probe. The bucket is to be rinsed with river water at each site prior to collecting sample.

- The thermistor or probe must be placed in the bucket immediately (not more than 5 minutes after water collection), before the temperature changes.
- The bucket must be shaded from direct sunlight and strong breezes before and during temperature measurement.
- The thermistor or probe must be allowed to equilibrate for at least 1 minute before temperature is recorded.

**pH**

Calibrate the pH sensor according to manufacturer directions. The pH function should be calibrated each day of use for multi-parameter instruments. To detect any drift in instrument reading during the course of sampling, post-calibration is recommended.

Preferably, pH is measured directly in-stream. Allow the pH probe to equilibrate for at least one minute before pH is recorded to the nearest 0.1 standard unit.

If pH cannot be measured in-stream, it should be measured in a bucket using the precautions outlined in the Temperature section.

**Dissolved Oxygen**

Dissolved oxygen (DO) is the oxygen freely available in water. DO is normally measured with a DO meter, preferably in place at the depth(s) specified earlier in this section. Refer to instrument manual for specific calibration requirements. The calibration value to be used when calibrating by the air saturation method can found in Appendix D.

Calibrate the DO sensor on the multi-parameter instrument. The DO probe must equilibrate for at least 90 seconds before DO is recorded to the nearest 0.1 mg/L. Care must be taken at profile stations to ensure that the reading is stable for each depth. Because DO takes the longest to stabilize, record this parameter after temperature, pH and specific conductance. When using the multimeter in waters flowing at less than one foot per second, it is recommended that the meter circulator be used to provide adequate flow for reliable dissolved oxygen readings. In waters having flows in excess of one foot per second, merely point the probe in the direction of the on-coming flow to obtain dissolved oxygen readings. To detect any drift in instrument readings during the course of sampling, post-calibration often is recommended.

If dissolved oxygen cannot be measured in-stream, it should be measured in a bucket using the precautions outlined in the Temperature section.

**Specific Conductance**

Preferably, specific conductance is measured directly in-stream at the depth(s) specified in this section. Calibrate the conductivity meter in the lab or field. Standards of known conductivity are required for calibration of multi-parameter instruments. Conductivity standards should be high enough to encompass expected stream measurements. This can

be obtained from historical data or general knowledge of an area. Allow the conductivity probe to equilibrate for at least one minute before specific conductance is recorded to three significant figures (if the value exceeds 100). The primary physical problem in using a specific conductance meter is entrapment of air in the conductivity probe chambers, which is indicated by unstable specific conductance values fluctuating to as much as 100 µS/cm. The entrapment of air can be minimized by slowly, carefully placing the probe into the water; when the probe is completely submerged, move it through the water quickly to release any air bubbles. To detect any drift in instrument readings during the course of sampling, post-calibration often is recommended.

If specific conductance cannot be measured in-stream, it should be measured in a bucket using the precautions outlined in the Temperature section.

## STEP 3. Collection of Representative River Water Samples

Preventing ambient water samples from becoming contaminated during the sampling and analytical process is one of the greatest challenges faced in the generation of water quality information. The Kentucky Ambient/Watershed Monitoring Assessment program contamination control policy is presented in Appendix E. Appendix F presents the quality control design for the program

The following sections provide a field reference for chain of custody procedures, sampling surface water and further procedures for measuring field variables and handling water quality samples.

### A. Chain of Custody Procedures

The Ambient/Watershed Monitoring Chain of Custody form (Appendix G) serves to document and record the transfer of the samples from the water body to the laboratory, functions as a field measurement form and provides a place for field observations. Listed are data elements of the chain of custody.

**Sample Identification**

- Report Number and Laboratory Number – this information is to be entered by laboratory
- Site Identification - name of sample site
- Station number
- Name of county where collected
- Collection date/time

**Field Measurements**

- Field measurements – temperature, specific conductance, pH, dissolved oxygen, turbidity, meter used and date calibrated
- Stage height or reference point measurement

**Variables**

- Sample matrix
- Container size and type
- Preservation – including acid lot number
- Variables to be analyzed

**Signatures**

- Sampler's identification
- Relinquished by
- Samples received at laboratory by

**Field observations**

- Sampling location (bridge, in-stream or boat)
- Flow conditions
- Hydrologic condition
- Weather at time of sampling
- Weather in past 24 hours
- Stream mixing
- Stream color
- General observations
- Stream shading

## B. River and Stream Sampling

Collect samples at the same bridge point or stream cross section throughout the period of record, if possible. This will eliminate many of the potential problems that might arise during the interpretation of the water quality data. This does not mean that the same section used during low-flow wading stage must be used during higher stages that require the use of a bridge. It is strongly recommended that, whenever possible, sampling be conducted by wading since this results in less chance of sample contamination, and it is safer. It is recommended that whenever possible, the field crew consist of two persons. It is felt that an additional crew member not only is more efficient, but is also a matter of safety. The decision whether to use two persons is at the discretion of the Division of Water field office supervisor.

**In-stream sampling**

Two sampling methods are available for in-stream sampling. These methods include direct grab sampling and the DH-81 sampler. Under most wading stage conditions, direct grab sampling will be employed. The DH-81 sampler is a depth-integrating sampler used when wading is possible but direct grab sampling is limited by stream depth. (For information regarding the DH-81 sampler visit the Federal Interagency Sedimentation

Project Internet page http://fisp.wes.army.mil/Catalog_Page_US_DH-81_Sampler.htm.) Disposable powderless latex gloves are to be worn when using either method.

**In-stream sampling safety**

A maximum safe wading depth depends on the size of the person sampling, the steram velocity and the streambed material. Each sampler should know and strictly adhere to hi/her personal wading limitations. Record stage heights/tapedown readings and whether stream was wadeable. Maintain in notebook for later reference when sampling. Caution should always be used when wading streams deeper than three feet. Additional caution should be used when the streambed is composed fo loose or slippery material. Algae-coated cobbles and bedrock can be slippery and dangerous as ice.

Sampling personnel should wear the following:

- Waders equipped with wading belt; waders should have felt soles to reduce slipping on stream bottoms
- USCG-approved Type-III floatation vest

In either method, the sampler approaches the stream from a downstream location, walking upstream to the sampling site. This is very important so as not to disturb bottom sediments that could contaminate the water quality sample. An ideal wading location is at the head of a riffle so that water current produces a good flow past the sampling point. First the sampler contaminates the gloves with stream water. Sample bottles are then contaminated with river water. Rinse pre-washed bottles (metals, pesticides and Mason jar used with DH-81 sampler) once with river water. Rinse bottles (bulk, nutrient), which have not been pre-cleaned, three times with river water. Whether using either the grab method or DH-81 sampler, the sample bottle is lowered from the surface to the bottom until the sample bottle touches the stream bottom. (When stream flow is low it is especially important to disturb bed sediments as little as possible.) Upon reaching the bottom, the sample bottle is raised to the surface. Try to approximate the same transit rate when lowering and raising the sampler. This action is repeated until the bottle is filled with stream water. Rinse the bottle cap in the stream and cap the bottle**.** At wadeable sites, water sample collection should be conducted in the centroid of flow if field measurements indicate the stream to be completely mixed from bank to bank. If field measurements do not indicate complete mixing, collect a composite sample at ¼, ½ and ¾ of the stream width.

**Bridge sampling**

Bridge sampling is recommended only when stream depths prevent in-stream sampling. Sampling from bridges not only increases danger to samplers, but also increases the potential of sample contamination from road dust and vehicle exhaust. It is essential that motorists be made aware of sampling activities. Protocol for installation of traffic control devices used in work zones is found in the Guidelines for Traffic Control in Work Zones http://www.ktc.uky.edu/archive_T2/WZTCb.pdf prepared by the University of Kentucky

Transportation Center in cooperation with the Kentucky Transportation Cabinet, Kentucky State Police and Federal Highway Administration.

**Sampling personnel should wear the following:**

- **Orange safety vest**

**Protocol for sampling at bridge crossings is presented in Appendix A.**

The weighted bottle sampler (WBS) is used when sampling off bridges. A single mid-channel sample is collected at bridge crossings. Ideally, a two-person crew should be employed. By utilizing two persons, the clean hands (CH)/dirty hands (DH) technique can be used. DH handles the WBS, raising and lowering it from the bridge. The DH never touches the sample bottle directly. CH is responsible for placing the bottle in the WBS and placing the cap on the bottle. CH is to wear powderless, latex gloves. CH should never touch the WBS or the bridge. If one person is using both the WBS and placing the caps on the sample bottles, multiple glove changes are required. After lowering and raising the WBS, a change of gloves is required for the single sampler technique before the sample bottle may again be handled.

Using either method, a sample bottle is lowered to the river and allowed to fill. Water collected is then used to fill and rinse the other sample bottles. Fill the other bottles about a quarter full with water. Cap, shake and discard rinse water. Recap until used. Place the cap face down in a ziplock bag while filling the sample bottles to reduce the chance of contaminating the cap with airborne pollutants.

To collect a water quality sample, place a capped bottle in the WBS. Whenever placing or removing a bottle from the WBS, recap bottle prior to swinging the WBS arm. This will prevent an inadvertent drop of water falling from the WBS arm into sample bottle. Lower the WBS holding bottle until it just reaches water surface. Allow current to carry the WBS downstream a little. Raise the WBS just above water's surface and allow it to swing under bridge. Release rope to lower WBS into water. Allow enough rope out so the WBS can touch bottom of stream directly under sampler. A little practice is needed, but this procedure can be done in a more or less fluid motion. Allow the current to carry the WBS downstream. When the WBS has stopped moving downstream, raise the sampler to the surface. Depending on the velocity of flow, it may take one to several times to fill bottle.

**Gage height measurements**

Gage height, or reference point measurements, are to be taken on each site visit. Discharge measurements will be conducted at various flows so that a rating curve can be developed. Recorded gage height measurements can be compared to the rating curve to determine stream discharge. Discharge information can then be used to calculate stream loading.

Gage height measurements are conducted at bridge crossings. Measurements are made using USGS wire-weight equipment where available.

At all bridge crossings at which wire-weight equipment is not available, tapedown measurements are required. At some point on the bridge, usually in mid-span on the downstream side of the bridge, a tapedown point is painted on the bridge. This point is painted on the first visit to the bridge. A chisel mark is also etched onto the bridge to facilitate locating the tapedown point in subsequent site visits. Tapedowns are made using a tape measure and an attached weight (i.e. gate hinge). When using either method, lower the weight until it barely touches the water surface. Record this value. When using the tapedown method, record the value in the following manner: tapedown distance + length of gate hinge. Tapedown measurements should be recorded in tenths of a foot.

Real-time gage heights can also be obtained for select USGS sites by going to the Internet at: http://water.usgs.gov/realtime.html.

**Fecal coliform and *Escherichia coli* bacteria**

Fecal coliform and *E. coli* bacteria are used to assess the quality of water because they are correlated to the presence of several waterborne disease-causing organisms (pathogens). The concentration of indicator bacteria (the term "indicator bacteria" is used synonymously with fecal coliform and *E. coli* indicator bacteria in this document) is a measure of public health safety for contact recreation or for consumption. The identification and enumeration of indicator bacteria measure the sanitary quality of water.

To collect samples for indicator bacteria in streams by wading, dip the sample container (sterile, unrinsed) to a depth of about 4 in. with the open end facing upstream. Push the mouth of the container upstream at this depth until the container is nearly full. The mouth of the container should at all times be upstream of the sample collector, sampling apparatus and any disturbed sediments. To collect samples for indicator bacteria in non-wadeable streams, attach sample container to a swivel attached to a fishing line. Lower the container from bridge to stream to collect sample. To collect samples for bacteria when using a boat, dip the container to a depth of about 4 in. The mouth of the container should be pushed at this depth away from the boat, sample collector, sampling apparatus and any disturbed sediment. Leave enough airspace (approximately 20%) in the top of the sample container to help mix the sample when it is shaken just before filtration. Bacteriological samples should be collected at the same locations as field measurements and water quality samples.

Always use a sterile container such as a disposable coliform sample bottle or a new Whirlpak bag to collect the sample. Immediately chill samples in an ice chest or refrigerator at $1^{o}$ to 4° C. Do not freeze samples. Deliver samples to the laboratory as soon as possible, ideally within six hours from time of collection. However, as long as from sample collection time to placement of prepared samples in incubator occurs within eight hours, the sample results will be valid. Begin preparation and incubation as quickly

as possible, preferably within one hour, but the process cannot exceed eight hours after sample collection to minimize changes in indicator bacteria density.

Microbiological laboratory procedures may be found in Methods for Assessing Biological Integrity of Surface Waters in Kentucky (Kentucky Department for Environmental Protection, Division of Water, Ecological Support Section. *Methods for Assessing Biological Integrity of Surface Waters in Kentucky*. Frankfort, Kentucky, 2005).

**Chlorophyll-*a***

Algae are responsive to changes in their physical environment. When particular conditions exist, such as extended photoperiod, low flow and high nutrient concentrations, algae reproduce rapidly creating nuisance growths or blooms. Trophic status of lakes and rivers may be based on chlorophyll-*a* levels. Chlorophyll-*a* is one approach used to estimate phytoplankton biomass. To gather information to determine the relationship between nutrient and phytoplankton biomass, chlorophyll-*a* concentrations are measured at selected large river ambient monitoring sites. A phytoplankton sample will also be collected to determine dominant "bloom" species.

**Sampling Design Protocol**

**Definition of water quality variable: chlorophyll-*a***

**Frequency of sampling:** Sampling will be conducted monthly during the period May through October whenever stable, low-flow conditions exist and elevated dissolved oxygen ($\geq$ 9 mg/L or $\geq$ 110% saturation) and pH ($\geq$ 8.0) are measured in the field, or greenish water color are met.

**Chlorophyll-*a* sampling locations:** Environmental conditions for the establishment of algal "blooms" are primarily met only in low-gradient riverine situations; sampling sites for chlorophyll-*a* are located at the lowest downstream ambient sampling sites in 8-digit hydrologic units

**Collection of chlorophyll-*a* samples:**

Grab Sample

Grab samples may be collected off a bridge. Samples are to be collected by submersing a 1-liter HDPE bottle to a depth of approximately 18 inches (roughly elbow length). Sample collection is similar to that method used for collecting euphotic zone samples in lakes or reservoirs.

**Sample labeling:** Chlorophyll-*a* samples are to be labeled with a waterproof permanent marker. The label should include stream name, date sampled and collector.

**Sample shipping:** Chlorophyll-*a* samples must be kept on ice and shipped overnight to:

Gillian Miller
Division of Water
Water Quality Branch
14 Reilly Road
Frankfort, KY 40601

**Sample processing:** Upon receipt of chlorophyll-*a* samples by the Water Quality Branch, samples are either to be refrigerated at 4$^{o}$C or filtered immediately. Samples may be held for up to 48 hours prior to filtering. Chlorophyll-*a* analysis should be performed within 30 days of sample collection.

## STEP 4. Collection of Representative Lake/Reservoir Water Samples

### NETWORK DESIGN

Kentucky lakes are currently sampled on a Watershed Management Framework Initiative approach. A total of 105 lakes that are listed in the Division of Water's lakes inventory are sampled every five years by basin management unit. Beginning in 1998, lakes have been sampled in order of basin management unit: 1) Kentucky River; 2) Salt and Licking Rivers; 3) Four Rivers (includes the Upper Cumberland, Lower Cumberland, Ohio, Mississippi and Tennessee rivers); 4) Green and Tradewater rivers; and 5) Big Sandy and Little Sandy rivers and Tygarts Creek. Ohio River minor tributary basins adjacent to the major river basins are sampled in the same year as the rest of the basin management unit.

### LAKE SAMPLING AND ANALYTICAL METHODOLOGY

#### Sampling Locations

Sampling site locations (Table 3) for Division of Water inventory lakes were established in 1984. Sample sites always include the deepest part of the lake near the dam. Mid-lake and upper lake stations were established depending on lake size and purpose of study. Lakes with major tributaries have sampling stations located in the embayment to fully assess the total acreage of the lake.

Water quality monitoring stations for major reservoirs that are managed by the U.S. Army Corps of Engineers are located and sampled at historical sampling sites that have been established for each lake by the U.S. Army Corps of Engineers (COE}.

Table 3. Kentucky clean lakes monitoring stations.

| Watershed | Station name | STA # | HYDRO UNIT | LAT (+) | LONG (-) |
|---|---|---|---|---|---|
| Big Sandy | Fishtrap Lake - dam | 138 | 05070202 | 37.43279 | 82.41643 |
| | Fishtrap Lake - Grapevine Creek | 139 | 05070202 | 37.42470 | 82.36890 |
| | Fishtrap Lake - Lick Creek | 140 | 05070202 | 37.40970 | 82.31170 |
| | Dewey Lake - dam | 135 | 05070203 | 37.73580 | 82.72720 |
| | Dewey Lake - just upstream of Brandykeg Embayment | 136 | 05070203 | 37.69908 | 82.72493 |
| | Dewey Lake - confluence of Dicks Creek | 137 | 05070203 | 37.69810 | 82.68220 |
| | Paintsville Lake - dam | 189 | 05070203 | 37.84137 | 82.87178 |
| | Paintsville Lake - upstream of Low Gap Branch | 190 | 05070203 | 37.88205 | 82.92733 |
| | Paintsville Lake - downstream of Open Fork | 191 | 05070203 | 37.89844 | 82.98633 |
| | Carter Caves Lake near Olive Hill | 062 | 05090103 | 38.36610 | 83.11860 |
| | Yatesville lake - dam | 193 | 05070204 | 38.12510 | 82.69730 |
| | Yatesville Lake - upstream of San Branch | 194 | 05070204 | 38.09137 | 82.71248 |
| | Yatesville Lake - Brushy Creek | 195 | 05070204 | 38.08924 | 82.74305 |
| | Greenbo Lake - dam | 063 | 05090104 | 38.49060 | 82.86720 |
| | Greenbo lake - Claylick Creek Arm | 064 | 05090104 | 38.48610 | 82.87440 |
| | Greenbo Lake - Buffalo Branch Arm | 065 | 05090104 | 38.84220 | 82.86970 |
| | Grayson Lake - dam | 212 | 05090104 | 38.25219 | 82.98513 |
| | Grayson Lake - downstream of Clifty Creek | 213 | 05090104 | 38.23390 | 83.00806 |
| | Grayson Lake - upstream of Bowling Branch | 214 | 05090104 | 38.19633 | 83.02999 |

Table 3 (cont.). Kentucky clean lakes monitoring stations.

| Watershed | Station name | STA # | HYDRO UNIT | LAT (+) | LONG (-) |
|---|---|---|---|---|---|
| Licking | Williamstown Lake - Goose Creek Arm | 041 | 05100101 | 38.66598 | 84.52822 |
| | Williamstown Lake - SF Grassy Creek Arm | 042 | 05100101 | 38.67634 | 84.53712 |
| | AJ Jolly Lake - dam | 043 | 05100101 | 38.87720 | 84.38560 |
| | AJ Jolly Lake - upper lake | 044 | 05100101 | 38.88500 | 84.36920 |
| | Kincaid Lake - dam | 045 | 05100101 | 38.72419 | 84.29052 |
| | Kincaid lake - upstream of Turkey Branch | 046 | 05100101 | 38.72190 | 84.27280 |
| | Doe Run Lake near Erlanger | 082 | 05100101 | 38.98692 | 84.55569 |
| | Sand Lick Creek Lake near Wallingford | 083 | 05100101 | 38.38607 | 83.61395 |
| | Greenbriar Lake near Upper Spencer | 047 | 05100101 | 38.01970 | 83.84780 |
| | Cave Run Reservoir | | 05100101 | | |
| | Lake Carnico near Carlisle | 084 | 05100102 | 38.34670 | 84.04170 |
| Kentucky | Fishpond Lake near Payne Gap | 058 | 05100201 | 37.15750 | 82.67890 |
| | Pan Bowl Lake near Jackson | 059 | 05100201 | 37.56816 | 83.38160 |
| | Buckhorn Lake - dam | 106 | 05100202 | 37.33830 | 83.47110 |
| | Buckhorn Lake - upstream of Rush Creek | 107 | 05100202 | 37.27399 | 83.44329 |
| | Buckhorn Lake - downstream of Wilder Branch | 108 | 05100202 | 37.26979 | 83.37925 |
| | Bert Combs Lake near Manchester | 086 | 05100203 | 37.16670 | 83.70750 |
| | Mill Creek Lake near Slade | 060 | 05100204 | 37.76701 | 83.67319 |

Table 3 (cont.). Kentucky clean lakes monitoring stations.

| Watershed | Station name | STA # | HYDRO UNIT | LAT (+) | LONG (-) |
|---|---|---|---|---|---|
| Kentucky (cont.) | Elmer Davis Lake near Owenton | 035 | 05100205 | 38.49539 | 84.88201 |
| | Bullock Penn Lake - dam | 036 | 05100205 | 38.78920 | 84.65670 |
| | Bullock Penn Lake - downstream of KY 491 | 037 | 05100205 | 38.79780 | 84.64390 |
| | Boltz Lake near Dry Ridge | 038 | 05100205 | 38.70580 | 84.61889 |
| | Corinth Lake near Corinth | 039 | 05100205 | 38.50440 | 84.58870 |
| | Stanford Reservoir near Standford | 085 | 05100205 | 37.48690 | 84.67860 |
| | Herrington Lake - dam | 091 | 05100205 | 37.77810 | 84.71140 |
| | Herrington Lake - Chimney Rock | 092 | 05100205 | 37.74890 | 84.70530 |
| | Herrington Lake - Sims Boat Dock | 093 | 05100205 | 37.71780 | 84.74170 |
| | Herrington Lake - downstream of Chenault Bridge | 094 | 05100205 | 37.67140 | 84.69000 |
| | Lake Reba near Richmond | 178 | 05100205 | 37.74110 | 84.25190 |
| | Cedar Creek Lake near Crab Orchard | 211 | 05100205 | 37.49567 | 84.55200 |
| Salt | Lake Jericho near | 080 | 05140101 | 38.44530 | 85.28140 |
| | Reformatory Lake near Buckner | 034 | 05140101 | 38.39986 | 85.43966 |
| | Guist Creek Lake – dam | 030 | 05140102 | 38.20810 | 85.15720 |
| | Guist Creek Lake - Tick Creek Arm | 031 | 05140102 | 38.20670 | 85.14110 |
| | Guist Creek Lake - upstream of KY 1779 | 032 | 05140102 | 38.22080 | 85.14920 |
| | Shelby Lake near Shelbyville | 078 | 05140102 | 38.23060 | 85.22080 |
| | McNeely Lake near Okolona | 033 | 05140102 | 38.09810 | 85.63580 |
| | Long Run Lake near Eastwood | 079 | 05140102 | 38.26640 | 85.41750 |
| | Marion Co. Sportman Lake near Calvery | 024 | 05140103 | 37.51327 | 85.24788 |

Table 3 (cont.). Kentucky clean lakes monitoring stations.

| Watershed | Station name | STA # | HYDRO UNIT | LAT (+) | LONG (-) |
|---|---|---|---|---|---|
| Salt (cont.) | Sympson Lake near Bardstown | 025 | 05140103 | 37.80750 | 85.51030 |
| | Willisburg Lake near Willisburg | 026 | 05140103 | 37.82756 | 85.16260 |
| | Beaver Lake - dam | 027 | 05140103 | 37.96250 | 85.02220 |
| | Beaver Lake - Beaver Creek Arm | 028 | 05140103 | 37.97190 | 85.1560 |
| Green | Campbellsville City Lake at Campbellsville | 007 | 05110001 | 37.35750 | 85.34140 |
| | Spurlington Lake near Spurlington | 008 | 05110001 | 38.38500 | 85.25530 |
| | Salem Lake near Hodgenville | 010 | 05110001 | 37.58940 | 85.71140 |
| | Shanty Hollow Lake near Genmore | 023 | 05110001 | 37.15530 | 86.39000 |
| | Metcalfe Co. Lake near Edmonton | 089 | 05110001 | 37.04359 | 85.60996 |
| | Liberty Lake near Liberty | 090 | 05110001 | 37.32103 | 84.89466 |
| | Freeman Lake near Elizabethtown | 009 | 05110001 | 37.71560 | 85.86920 |
| | Mill Creek Lake near Tompkinsville | 088 | 05110002 | 36.68250 | 85.70080 |
| | Spa Lake near Spa | 005 | 05110003 | 36.94980 | 87.02954 |
| | Lake Malone - dam | 019 | 05110003 | 37.08080 | 87.03330 |
| | Lake Malone - Clifty Creek Arm | 020 | 05110003 | 37.05080 | 87.03940 |
| | Lake Malone - Sulphur Spring Arm | 021 | 05110003 | 37.06586 | 87.06252 |
| | Luzerne Lake near Greenville | 022 | 05110003 | 37.21280 | 87.19690 |
| | Briggs Lake near Russellville | 071 | 05110003 | 36.88780 | 86.83280 |
| | Washburn Lake near Dukehurst | 076 | 05110004 | 37.51810 | 86.84890 |
| | Grapevine Lake near Madisonville | 016 | 05110006 | 37.30530 | 87.47670 |

Table 3 (cont.). Kentucky clean lakes monitoring stations.

| Watershed | Station name | STA # | HYDRO UNIT | LAT (+) | LONG (-) |
|---|---|---|---|---|---|
| Green (cont.) | Lake Beshear - dam | 011 | 05140205 | 37.14810 | 87.68202 |
| | Lake Beshear - Clifty Creek Arm | 012 | 05140205 | 37.13330 | 87.67530 |
| | Lake Beshear - Piney Creek Arm | 013 | 05140205 | 37.12810 | 87.69860 |
| | Loch Mary near Earlington | 014 | 05140205 | 37.27330 | 87.52030 |
| | (New) Providence City Lake near Providence | 072 | 05140205 | 37.37497 | 87.79705 |
| | Moffit Lake near Pride | 073 | 05140205 | 37.57860 | 87.85470 |
| | Carpenter Lake near Maceo | 018 | 05140201 | 37.84560 | 86.98140 |
| | Kingfisher Lake near Maceo | 075 | 05140201 | 37.84470 | 86.97690 |
| | Mauzy Lake near Boxville | 017 | 05140202 | 37.62220 | 87.85580 |
| | Scenic Lake near Henderson | 074 | 05140202 | 37.87830 | 87.56190 |
| | Lake George near Marion | 004 | 05140203 | 37.30304 | 88.09060 |
| Cumberland | Corbin Reservoir - dam | 052 | 05130101 | 36.97073 | 84.12002 |
| | Corbin Reservoir - upper lake | 053 | 05130101 | 36.99251 | 84.12050 |
| | Chenoa Lake near Chenoa | 055 | 05130101 | 36.67640 | 83.85060 |
| | Cannon Creek Lake near Ferndale | 056 | 05130101 | 36.68050 | 83.69390 |
| | Cranks Creek Lake near Smith | 057 | 05130101 | 36.73830 | 83.23750 |
| | Laurel Creek Lake near Whitley City | 087 | 05130101 | 36.68940 | 84.44310 |
| | Lake Linville near Renfro Valley | 049 | 05130102 | 37.38610 | 84.34030 |
| | Wood Creek Lake - dam | 050 | 05130102 | 37.21280 | 84.19830 |

Table 3 (cont.). Kentucky clean lakes monitoring stations.

| Watershed | Station name | STA # | HYDRO UNIT | LAT (+) | LONG (-) |
|---|---|---|---|---|---|
| Cumberland (cont.) | Wood Creek Lake - at boat dock | 051 | 05130102 | 37.18670 | 84.17690 |
| | Tyner Lake near Tyner | 054 | 05130102 | 37.37853 | 83.91289 |
| | Energy Lake near Golden Pond | 001 | 05130205 | 36.86170 | 88.01530 |
| | Lake Blythe near Hopkinsville | 069 | 05130205 | 36.92310 | 87.49640 |
| | Lake Morris near Hopkinsville | 070 | 05130205 | 36.92030 | 87.45580 |
| Four Rivers | Turner Lake near Oscar | 067 | 05140206 | 37.17610 | 89.03970 |
| | Metropolis Lake near Grahamville | 121 | 05140206 | 37.14780 | 88.76670 |
| | Swan Pond Lake near East Cairo | 124 | 08010100 | 37.01338 | 89.11803 |
| Discontinued | Campton Lake near Campton | 061 | 05100204 | 37.74500 | 83.54690 |
| due to access | Flat Lake near Barlow | 066 | 08010100 | 37.04030 | 89.09920 |
| or restrictions. | Caneyville Lake near Caneyville | 077 | 05110004 | 37.43931 | 86.46386 |
| | Owsley Fork Lake near Berea | 209 | 05100205 | 37.54558 | 84.18237 |

**Sampling Frequency**

Lake sampling for trophic status determination is conducted three times during the growing season (April – October).

**Sample Collection Methodology**

1. A 3-liter non-metallic Kemmerer sampler and 12-liter Nalgene nonporous plastic sample containers are used to collect and composite lake samples. The Nalgene container and the Kemmerer sampler are thoroughly pre-cleaned and rinsed in the laboratory before going to the field. The Nalgene sample container and the Kemmerer sampler are both field rinsed with the lake water before collecting samples.

2. At time of sample collection, station header information is entered in waterproof ink or pencil on the Lake Data Sheet (Appendix H). Station header information includes: STORET number, lake name, date, time and station site name. Lake conditions and field observations should be entered in the space reserved for notes.

3. Containers, preservation techniques and holding times for eutrophication lake samples are listed in Table 2.

4. Alkalinity, nutrients and chlorophyll-*a* variables are analyzed in composite samples. The composite sample is based on the depth of the euphotic zone. The euphotic zone (depth of 1% surface illumination) is measured at each station during each sampling period using a submersible photometer. When the depth of the euphotic zone is determined, samples are collected by submersing the non-metallic Kemmerer sampler at the surface and at evenly spaced one meter intervals throughout the euphotic zone. Water samples are then collected at each depth and combined so that a euphotic zone composite sample is obtained.

**Field Processing of Samples**

1. Duplicate samples for chlorophyll-*a* analyses are filtered in the field. Filtering is conducted using 24 mm diameter, Whatman GF/C glass fiber filters and a calibrated 50-milliliter (mL) calibrated pipet. A 50-mL volume of sample is generally adequate for most lakes to tint the glass fiber filter paper with a greenish or brownish color. Sometimes a 100-mL volume is necessary in oligotrophic waters. The glass fiber filters from the field filtration are sealed in opaque camera film containers separated by aluminum foil, placed on wet ice and returned to the laboratory where they are frozen until analyzed.

2. Water samples to be analyzed for dissolved organic carbon, total soluble (total dissolved) phosphorus and soluble reactive orthophosphate are filtered in the field. A Gelman GN-6 Metricel filter (0.45 micron, 47-mm diameter) and a calibrated magnetic funnel are used to filter an aliquot of the composite sample. The sample is then placed in a 30-mL round Nalgene bottle for total dissolved phosphorus and

soluble reactive phosphorus (orthophosphate) and a 60-mL square Nalgene bottle for dissolved organic carbon. The samples are preserved on wet ice and returned to the laboratory.

3. Sample cubitainers are rinsed with composite sample before filling. The outside of the cubitainer is marked with a waterproof marker with station Clean Lakes Number (CLN), station location description, station letter for multiple lake stations, time, date, parameters to be analyzed and the initials of the collectors. Samples are then preserved with appropriate acids and placed on wet ice.

**Field Measurements**

1. Water temperature, pH, dissolved oxygen and specific conductance are measured at the surface and then one-meter depth intervals to a depth of 20 m and then to approximately ½ meter from the bottom in five-meter intervals. A multiparameter probe with a 50 m cable is used in measuring these variables by lowering the sonde unit to the desired depths. Temperature ($^{o}$C), pH SU (standard units), dissolved oxygen (mg/L) and specific conductance µS/cm) are recorded directly from the meter readings and entered on the Lake Data Sheet.

2. Visibility or visible light penetration is determined using a Secchi disk and "aquascope" viewer. The Secchi disk is submersed to point of disappearance on the shady side of the boat. This depth is noted. The disk is lowered a few feet more, then slowly raised until it reappears. This depth is noted. The average of these two readings is taken for the final Secchi disk visibility depth and estimated to the nearest 0.1 foot and later converted into meters.

3. Euphotic zone depth is determined by using a Protomatic or Licor LI-185b Underwater Photometer. On the sunny side of the boat, the photometer probe is lowered just below the water surface. Note reading. Calculate 1% of this value (depth of euphotic zone) and adjust meter to range in which the calculated value lies. The photometer probe is lowered to the depth at which the meter gives the calculated value. Depth of probe in meters and tenths of meters and light intensity in foot-candles are recorded on the field sheet.

## STEP 5. Preservation

Sample preservation is the measure or measures taken to prevent reduction or loss of water quality variables of interest. Variable loss can occur between sample collection and laboratory analysis because of physical, chemical and biological processes that result in chemical precipitation, adsorption, oxidation, reduction, ion exchange, degassing or degradation. Preservation stabilizes variable concentrations for a limited period of time. Some samples have a very short holding time. Verify that time-dependent samples were received in proper condition, at the correct temperature and that holding times were not exceeded.

**Before going into the field:**

1. Check sample requirements for chilling and chemical treatment.
2. Check with the laboratory and make note of holding times.

**Chilling**

Immediately following sample collection and processing, samples that require chilling must be packed in ice or placed in a refrigerator and maintained at 4° C plus or minus 2° C, without freezing, until analyzed.

- Check that there is sufficient headspace in the sample bottle to allow for sample expansion.
- Put foam sleeves or bubble wrap around samples in glass bottles before packing them in ice.

**Chemical Treatment (Preservation)**

Chemical treatment may be either conducted at each site, at the last sampling site of the day or on the day of collection in the office prior to shipment. The two latter approaches are recommended since it requires setup of a preservation chamber only once[1]. Additionally, preservation at the lab either under a lab hood or field preservation chamber eliminates chance of windblown particles contaminating samples.

Chemicals used for sample preservation depend on the target variable. The most frequently used chemical preservatives by the Kentucky Ambient/Watershed Monitoring Assessment are provided in individual vialservatives and contain one of the following: nitric acid ($HNO_3$), sulfuric acid ($H_2SO_4$), hydrochloric acid (HCL) or monochloroacetic acid potassium acetate buffer. Sample preservation, along with sample designations and container requirements, are listed on the chain of custody. The preservatives are procured from the Ambient Monitoring Coordinator. Take steps to minimize sample contamination and maximize safety during the preservation process. Note that a chemical preservative for one sample may be a source of contamination for another. It is recommended that in order to help reduce contamination during the preservation process and ensure proper handling of chemicals:

- Work inside a preservation chamber (only the Clean Hands person works inside the chamber). Change gloves each time a different type of chemical treatment is used. Clean Hands/Dirty Hands techniques must be used for parts-per-billion levels of trace metals and are recommended for use in general and as appropriate for the study.
- Use preservatives packaged in individual vialservatives for routine preservation. Be aware that preservatives dispersed from dropper-type bottles or automatic pipettes

[1] The use of preservation chambers reduces the possibility of contamination and is required during sample preservation. These chambers are handmade. Generally a 2- by 2- by 2-ft frame is constructed using 1/4-in. PVC pipe to support a clear plastic bag, which forms a protective tent to work inside when preserving samples.

could become contaminated and could result in the contamination of subsequent samples.

- Use the grade of preservative appropriate to meet data-quality requirements.
- Always store preservatives in separate, sealed containers, preferably away from each other and away from environmental and quality-control samples.
- Follow a prescribed order in which samples are to be preserved (the recommended order is described in the steps below).

1. Put on disposable, powderless gloves.
2. Set up preservation chambers and assemble equipment and solutions in order in which they are used.
3. Acidify samples in following order:
    - Nutrients – sulfuric acid (1mL 1:1/liter)
    - Metals – nitric acid (2mL 1:1/liter)
    - Low level Hg – hydrochloric acid (5mL conc./liter)
    - N-methylcarbamates (Pesticides method 531.1) – monochloroacetic acid
4. Tighten cap on sample bottle immediately after adding acid and invert five times to mix.
5. Disassemble the chamber frame.

## STEP 6. Handling and Packing of Samples

Samples should be packaged and shipped to DES for analysis as soon as possible. Generally, the shorter the time between sample collection/processing and sample analysis, the more reliable the analytical results will be. Before shipping to the laboratory:

- Check that sample bottles are labeled correctly.
- Complete chain of custody form fully completing all required information.
- Pack samples carefully in the shipping container to prevent bottle breakage, shipping container leakage and sample degradation. Check that bottle caps are securely tightened (don't over tighten though).

A summary of procedures for shipping samples to DES is outlined below.

**Labeling sample bottles**

Each sample bottle must be correctly labeled with the station identification number, date, time and sample group.

- Label each bottle with preprinted labels that will remain securely attached to the bottles even if they become wet. Use a permanent, waterproof marker to enter information on label. Eagle-Picher labels have been found to remain attached to plastic bottles under wet conditions. However, these labels will come off glass bottles

when wet. Always attach labels prior to collecting samples. For glass bottles, after attaching labels, wrap clear shipping tape completely around bottle covering label.

- Write legibly and include as a minimum the following information:
  1. Station identification number
  2. Date and time of collection
  3. Sample group (bulk, nutrient, metals, 507/508, and so on)
  4. Initials of person collecting samples

**Packing samples**

When packaging samples for shipment to DES, remember that all bottles must be protected from breaking and leaking. DES will return the cooler.

***When packaging samples:***

- Make sure bottle labels are waterproof and that information is legible.
- Tighten all bottle caps to prevent leakage.
- Double bag coolers using large size garbage bags. It is recommended that 40 – 45 gallon bags, 1.5 ml or more in thickness, be used in lining coolers.
- Use adequate packaging material to prevent leakage.
  1. Ship all glass bottles in foam sleeves or wrap them in bubble wrap.
  2. Pack glass bottles so they touch each other as little as possible.
  3. Place each sample bottle in a separate zip-lock bag.
- Pack samples designated for chilling in coolers.
  1. Use insulated ice coolers. **Do not use broken or leaky coolers.**
  2. Pack samples designated for chilling with loose ice. **Do not use milk jugs with frozen water.**
  3. The volume of ice should be equal to or greater than the volume occupied by samples (twice the volume of ice is recommended during warm weather).
  4. The amount of ice necessary will vary depending on the length of time in transit and ambient air temperature. Chilling the cooler and samples prior to shipment is recommended during hot weather.
  5. **Do not use blue ice or other types of commercial refreezing containers that have freezing points below 0°C.** This can cause bottles to freeze and result in ruined samples or broken bottles.
  6. Seal cooler spouts or drains with silicone or epoxy.
- After samples and ice are placed in doubled plastic bags, close each bag separately with a knot.
- Inside coolers:
  1. Place chain of custody in ziplock bag. Affix ziplock bag to underside of the cooler lid.
  2. Label the inside of each cooler lid with the current return address and telephone number, using a permanent waterproof marker.

# V. Data Management

Consistent data entry on the AMBIENT/WATERSHED MONITORING, CHAIN OF CUSTODY form and LAKE DATA SHEET is essential. This information serves as the basis for electronic entry of the data into the Division of Environmental Services (DES) database and the STORET database.

The most critical information for proper sample identification is the station ID, date and time of sampling, sample matrix and type of analysis requested (i.e. bulk, nutrient, metals, etc.)

All routine QC samples should be associated with an environmental sample. Do not use fictitious station ID numbers for routine QC samples.

The Water Quality Branch will enter field and bacteria data. All field and DES laboratory results are to be entered into the national STORET database within one year of collection.

# Appendix A
# Traffic Control at Bridge Crossings

# Traffic Control at Bridge Crossings

It is recognized that bridge sampling places field personnel in a potential high-risk environment and should not be taken lightly. Establishment of work zones at bridge crossings was strongly recommended. Procedures for installation of traffic control devices used in work zones listed in the SOP were taken from the Guidelines for Traffic Control in Work Zones http://www.ktc.uky.edu/archive_T2/WZTCb.pdf (see page 29) prepared by the University of Kentucky Transportation Center in cooperation with the Kentucky Transportation Cabinet, Kentucky State Police and Federal Highway Administration. The section on traffic control in the Kentucky SOP was designed to reflect that used by the USGS.

Fundamental principles in the SOP:

1. Ideally, do not locate sampling sites on high volume highways.
2. Traffic movement should be inhibited as little as practicable.
3. Motorists should be guided in a clear and positive manner while approaching and traversing temporary traffic control areas. The total traffic control system must meet three requirements:
    - Provide drivers advance warning;
    - Make the work area visible; and
    - Direct traffic around the work area.

4. All traffic control devices shall be removed immediately when not in use.
5. Only those who are trained in safe traffic control practices shall supervise the placement of traffic control devices in temporary work areas.

The SOP listed the following mandatory traffic devices:

1. orange reflective vest
2. minimum of four cones
3. warning signs (2) with the warning "**BRIDGE WORK AHEAD**"
4. vehicle roof strobe yellow light

At all sites where bridge sampling is required due to high flows or stream depth presenting unsafe wading conditions, it is recommended that traffic control be instituted following page 21 of the Guidelines for Traffic Control in Work Zones. This page presents guidelines for shoulder work with minor encroachment. This protocol modification replaces the existing protocol in the 2002 Kentucky Ambient/Watershed Water Quality Monitoring Standard Operating Procedure Manual.

Points of emphasis are listed below (not necessarily listed in importance):

1. Proper safety equipment must be available for samplers at each regional office.
2. Sampling plans must be prepared for all sampling locations where bridge sampling will be conducted.
3. Existing safety devices must be maintained.
4. Regional personnel must be trained in proper sampling safety.

**Protocol for sampling at bridge crossings**

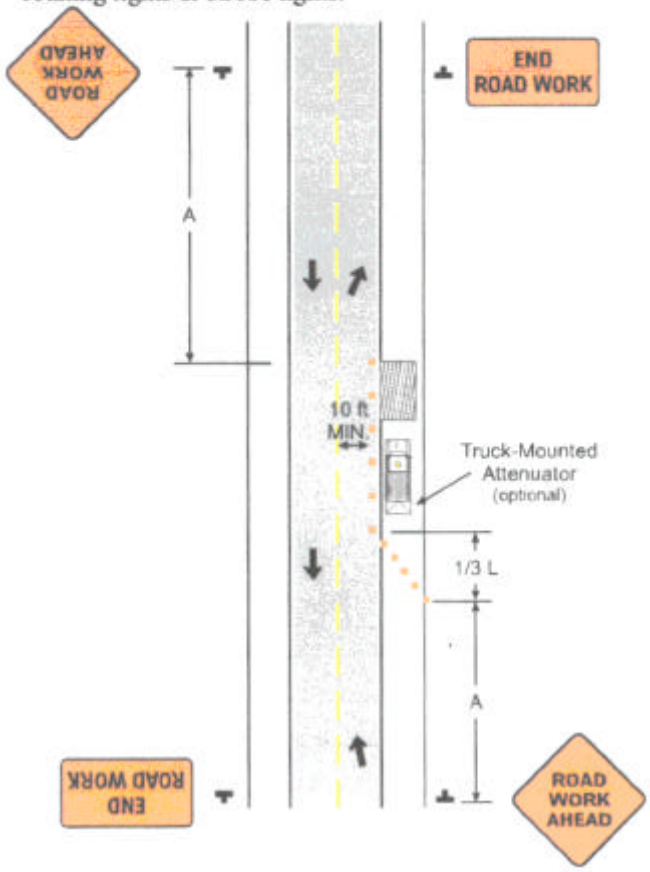
1. All field personnel shall wear orange safety vests. Prepare all bottles and other sampling gear prior to moving onto bridge. Stay on bridge no longer than necessary to collect samples.
2. Place strobe light on roof of vehicle and turn on. Turn on headlights and emergency lights.
3. Set up warning signs to indicate to both lanes of traffic that work activity is being conducted on bridge. Signs should be set back from the roadway between 6 to 12 feet. It may be necessary to weight signs down with bags of sand to prevent blowing over by high winds or vehicular traffic.
4. Set up cones, establishing taper and work zones.
5. Work as efficiently as possible following manual protocol. When sampling is completed, remove cones.
6. When sample handling is completed, dismantle warning signs. Remove strobe light from vehicle roof.

Table A-1. General guidelines for work zone approach and taper zone lengths on two-lane roads.

| Speed Limit (MPH) | Approach (feet) | Taper (feet) |
|---|---|---|
| 25 and Below | 200 | 70 |
| 26-35 | 200 | 130 |
| 36-40 | 200 | 160 |
| 45 | 350 | 280 |
| 55 | 500 | 330 |

## Shoulder Work with Minor Encroachment (TA-6)

All lanes should be a minimum of 10 feet in width as measured to the near face of the channelizing devices. The treatment shown should be used on a minor road having low speeds. For higher-speed traffic conditions, a lane closure should be used. Although vehicle hazard warning signals can be used to supplement the rotating lights or strobe lights, they shall not be used instead of rotating lights or strobe lights.



# Appenpdix B
# Water Sampling Supplies Checklist

## Water Sampling Supplies Checklist

### Field Survival

- ☐ Map of station locations
- ☐ Business card or ID
- ☐ Authorization (letter, etc.)
- ☐ Field notebook
- ☐ Waterproof pens, markers and pencils
- ☐ Trip routing forms
- ☐ Road log
- ☐ Photo log forms
- ☐ Field data forms
- ☐ Chain of custody forms
- ☐ Keys or security codes for gates and locks
- ☐ WD-40 for locks
- ☐ First aid kit, knife
- ☐ Insect repellent (wash hands thoroughly after applying)
- ☐ Hat, sunscreen, drinking water
- ☐ Sunglasses or safety glasses
- ☐ Leather gloves
- ☐ Waders
- ☐ Rain gear
- ☐ Toolbox with basic tools
- ☐ Tape measure
- ☐ Flashlight and extra batteries
- ☐ 2-way radio/cellular phone
- ☐ Weather radio
- ☐ Uniform
- ☐ Rope
- ☐ Fire extinguisher (type B)

### Physical Positioning

- ☐ Camera, film
- ☐ Site map
- ☐ Global positioning system (optional)

**Field Parameter Measurement**

- ☐ Tape measure
- ☐ Calculator
- ☐ Non-mercuric thermometers (2)
- ☐ pH meter and buffers, pH indicator strips
- ☐ Temperature, Conductivity, Redox, Dissolved Oxygen meters, probes and batteries
- ☐ Multimeter
- ☐ Copies of manufacturers' manuals for field equipment

**Surface Water**

- ☐ Coolers
- ☐ Sample containers as required by sampling plan
- ☐ Bags of ice
- ☐ Field preservation chamber frame and garbage bags
- ☐ 1-gallon ziplock bags
- ☐ Garbage bags for lining coolers
- ☐ Paper towels, KIM-wipes
- ☐ Acid preservatives (i.e. $HNO_3$, $H2SO_4$, HCL)
- ☐ VOA vials (for volatile organics)
- ☐ Whatman glass fiber lifters for chlorophyll-a filtering
- ☐ Disposable powder-free latex gloves

**Microbial Sampling**

- ☐ Sterilized Whirl-pak bags or sterile plastic bottles (for fecal coliform and E. Coli samples)

# Appendix C
# Field Meter Audit

## Field Meter Audit

Field meter audits are a quality assurance procedure to ensure that field meters are both working and calibrating properly; thus, providing water quality data of integrity. Audits will be conducted twice yearly - once in the spring and again in the fall. Specific conductance and pH probes (meters) will be evaluated during the audit.

### Audit procedure

At the time of the audit, unknowns for pH and specific conductance will be sent to the regional offices and others wishing to participate in the audit. The unknowns will consist of two one-liter bottles. One bottle is to be used for the pH audit; the other for the specific conductance audit. After allowing the unknowns to come to room temperature, water from the bottles is measured for pH and specific conductance. The results are entered in the form below and e-mailed to the Ambient Monitoring Coordinator. After all results have been received, the measurements will be evaluated for precision.

### Source of unknowns

Unknowns will come from samples of native stream water. Sources will come from a variety of sites across the state. The sample water will be collected and then filtered through a 0.45-micron filter. The water will be filtered directly into the bottles to be sent to the regional offices.

### Audit precision

Upon receiving all results, the relative precision of the results will be determined. Since the true value of the sample will never be known, the average of all results will be assumed the true value.

$$\text{Percent relative error} = \frac{(\text{True value} - \text{measured value})}{\text{True value}} \times 100$$

The results will also be evaluated to see if they differ from the expected value. This is a test to see if results fall within a certain confidence level. For the purposes of the meter audit a confidence level of 95% has been chosen.

Mean (±) of all results as determined: Student t variate X standard deviation/number of samples. If a result falls within the confidence level interval, the result is accepted as valid.

### Reporting of Audit results

Results will be forwarded to individuals participating in a prompt manner, along with corrective measures if needed.

# Appendix D
# Tables for Dissolved Oxygen Concentration, Oxygen Solubility in Water, and Correction Factor for Oxygen Saturation at Altitude

**TABLE D-1. KENTUCKY DIVISION OF WATER SATURATION CONCENTRATION OF DISSOLVED OXYGEN BY ELEVATION**

**ELEVATION = 300**

| TEMP | X.1 | X.2 | X.3 | X.4 | X.5 | X.6 | X.7 | X.8 | X.9 | X.10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 14.49 | 14.44 | 14.40 | 14.36 | 14.32 | 14.28 | 14.25 | 14.21 | 14.17 | 14.13 |
| 1 | 14.09 | 14.05 | 14.01 | 13.97 | 13.93 | 13.90 | 13.86 | 13.82 | 13.78 | 13.74 |
| 2 | 13.71 | 13.67 | 13.63 | 13.59 | 13.56 | 13.52 | 13.48 | 13.45 | 13.41 | 13.38 |
| 3 | 13.34 | 13.30 | 13.27 | 13.23 | 13.20 | 13.16 | 13.13 | 13.09 | 13.06 | 13.02 |
| 4 | 12.99 | 12.95 | 12.92 | 12.88 | 12.85 | 12.82 | 12.78 | 12.75 | 12.71 | 12.68 |
| 5 | 12.65 | 12.61 | 12.58 | 12.55 | 12.52 | 12.48 | 12.45 | 12.42 | 12.39 | 12.35 |
| 6 | 12.32 | 12.29 | 12.26 | 12.23 | 12.20 | 12.17 | 12.13 | 12.10 | 12.07 | 12.04 |
| 7 | 12.01 | 11.98 | 11.95 | 11.92 | 11.89 | 11.86 | 11.83 | 11.80 | 11.77 | 11.74 |
| 8 | 11.71 | 11.68 | 11.65 | 11.62 | 11.59 | 11.57 | 11.54 | 11.51 | 11.48 | 11.45 |
| 9 | 11.42 | 11.40 | 11.37 | 11.34 | 11.31 | 11.28 | 11.26 | 11.23 | 11.20 | 11.17 |
| 10 | 11.15 | 11.12 | 11.09 | 11.07 | 11.04 | 11.01 | 10.99 | 10.96 | 10.93 | 10.91 |
| 11 | 10.88 | 10.86 | 10.83 | 10.81 | 10.78 | 10.75 | 10.73 | 10.70 | 10.68 | 10.65 |
| 12 | 10.63 | 10.60 | 10.58 | 10.55 | 10.53 | 10.51 | 10.48 | 10.46 | 10.43 | 10.41 |
| 13 | 10.38 | 10.36 | 10.34 | 10.31 | 10.29 | 10.27 | 10.24 | 10.22 | 10.20 | 10.17 |
| 14 | 10.15 | 10.13 | 10.11 | 10.08 | 10.06 | 10.04 | 10.01 | 9.99 | 9.97 | 9.95 |
| 15 | 9.93 | 9.90 | 9.88 | 9.86 | 9.84 | 9.82 | 9.80 | 9.77 | 9.75 | 9.73 |
| 16 | 9.71 | 9.69 | 9.67 | 9.65 | 9.63 | 9.61 | 9.58 | 9.56 | 9.54 | 9.52 |
| 17 | 9.50 | 9.48 | 9.46 | 9.44 | 9.42 | 9.40 | 9.38 | 9.36 | 9.34 | 9.32 |
| 18 | 9.30 | 9.28 | 9.26 | 9.24 | 9.23 | 9.21 | 9.19 | 9.17 | 9.15 | 9.13 |
| 19 | 9.11 | 9.09 | 9.07 | 9.05 | 9.04 | 9.02 | 9.00 | 8.98 | 8.96 | 8.94 |
| 20 | 8.93 | 8.91 | 8.89 | 8.87 | 8.85 | 8.84 | 8.82 | 8.80 | 8.78 | 8.77 |
| 21 | 8.75 | 8.73 | 8.71 | 8.70 | 8.68 | 8.66 | 8.64 | 8.63 | 8.61 | 8.59 |
| 22 | 8.58 | 8.56 | 8.54 | 8.52 | 8.51 | 8.49 | 8.47 | 8.46 | 8.44 | 8.43 |
| 23 | 8.41 | 8.39 | 8.38 | 8.36 | 8.34 | 8.33 | 8.31 | 8.30 | 8.28 | 8.26 |
| 24 | 8.25 | 8.23 | 8.22 | 8.20 | 8.18 | 8.17 | 8.15 | 8.14 | 8.12 | 8.11 |
| 25 | 8.09 | 8.07 | 8.06 | 8.04 | 8.03 | 8.01 | 8.00 | 7.98 | 7.97 | 7.95 |
| 26 | 7.97 | 7.95 | 7.94 | 7.92 | 7.91 | 7.89 | 7.88 | 7.86 | 7.85 | 7.83 |
| 27 | 7.82 | 7.80 | 7.79 | 7.77 | 7.76 | 7.74 | 7.73 | 7.71 | 7.70 | 7.68 |
| 28 | 7.67 | 7.66 | 7.64 | 7.63 | 7.61 | 7.60 | 7.58 | 7.57 | 7.56 | 7.54 |
| 29 | 7.53 | 7.51 | 7.50 | 7.48 | 7.47 | 7.46 | 7.44 | 7.43 | 7.41 | 7.40 |
| 30 | 7.39 | 7.37 | 7.36 | 7.34 | 7.33 | 7.32 | 7.30 | 7.29 | 7.28 | 7.26 |

**TABLE D1 (cont.). KENTUCKY DIVISION OF WATER SATURATION CONCENTRATION OF DISSOLVED OXYGEN BY ELEVATION**

| | ELEVATION = 400 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **TEMP** | **X.1** | **X.2** | **X.3** | **X.4** | **X.5** | **X.6** | **X.7** | **X.8** | **X.9** | **X.10** |
| 0 | 14.43 | 14.39 | 14.35 | 14.31 | 14.27 | 14.23 | 14.19 | 14.15 | 14.11 | 14.07 |
| 1 | 14.03 | 14.00 | 13.96 | 13.92 | 13.88 | 13.84 | 13.80 | 13.77 | 13.73 | 13.69 |
| 2 | 13.65 | 13.62 | 13.58 | 13.54 | 13.51 | 13.47 | 13.43 | 13.40 | 13.36 | 13.33 |
| 3 | 13.29 | 13.25 | 13.22 | 13.18 | 13.15 | 13.11 | 13.08 | 13.04 | 13.01 | 12.97 |
| 4 | 12.94 | 12.90 | 12.87 | 12.84 | 12.80 | 12.77 | 12.73 | 12.70 | 12.67 | 12.63 |
| 5 | 12.60 | 12.57 | 12.53 | 12.50 | 12.47 | 12.44 | 12.40 | 12.37 | 12.34 | 12.31 |
| 6 | 12.28 | 12.25 | 12.21 | 12.18 | 12.15 | 12.12 | 12.09 | 12.06 | 12.03 | 12.00 |
| 7 | 11.97 | 11.94 | 11.91 | 11.88 | 11.85 | 11.82 | 11.79 | 11.76 | 11.73 | 11.70 |
| 8 | 11.67 | 11.64 | 11.61 | 11.58 | 11.55 | 11.52 | 11.49 | 11.47 | 11.44 | 11.41 |
| 9 | 11.38 | 11.35 | 11.33 | 11.30 | 11.27 | 11.24 | 11.22 | 11.19 | 11.16 | 11.13 |
| 10 | 11.11 | 11.08 | 11.05 | 11.03 | 11.00 | 10.97 | 10.95 | 10.92 | 10.89 | 10.87 |
| 11 | 10.84 | 10.82 | 10.79 | 10.77 | 10.74 | 10.72 | 10.69 | 10.66 | 10.64 | 10.61 |
| 12 | 10.59 | 10.57 | 10.54 | 10.52 | 10.49 | 10.47 | 10.44 | 10.42 | 10.39 | 10.37 |
| 13 | 10.35 | 10.32 | 10.30 | 10.28 | 10.25 | 10.23 | 10.21 | 10.18 | 10.16 | 10.14 |
| 14 | 10.11 | 10.09 | 10.07 | 10.05 | 10.02 | 10.00 | 9.98 | 9.96 | 9.93 | 9.91 |
| 15 | 9.89 | 9.87 | 9.85 | 9.82 | 9.80 | 9.78 | 9.76 | 9.74 | 9.72 | 9.70 |
| 16 | 9.68 | 9.65 | 9.63 | 9.61 | 9.59 | 9.57 | 9.55 | 9.53 | 9.51 | 9.49 |
| 17 | 9.47 | 9.45 | 9.42 | 9.41 | 9.39 | 9.37 | 9.35 | 9.33 | 9.31 | 9.29 |
| 18 | 9.27 | 9.25 | 9.23 | 9.21 | 9.19 | 9.17 | 9.15 | 9.14 | 9.12 | 9.10 |
| 19 | 9.08 | 9.06 | 9.04 | 9.02 | 9.00 | 8.99 | 8.97 | 8.95 | 8.93 | 8.91 |
| 20 | 8.89 | 8.88 | 8.86 | 8.84 | 8.82 | 8.80 | 8.79 | 8.77 | 8.75 | 8.73 |
| 21 | 8.72 | 8.70 | 8.68 | 8.66 | 8.65 | 8.63 | 8.61 | 8.60 | 8.58 | 8.56 |
| 22 | 8.55 | 8.53 | 8.51 | 8.49 | 8.48 | 8.46 | 8.44 | 8.43 | 8.41 | 8.40 |
| 23 | 8.38 | 8.36 | 8.35 | 8.33 | 8.31 | 8.30 | 8.28 | 8.27 | 8.25 | 8.23 |
| 24 | 8.22 | 8.20 | 8.19 | 8.17 | 8.16 | 8.14 | 8.12 | 8.11 | 8.09 | 8.08 |
| 25 | 8.06 | 8.05 | 8.03 | 8.02 | 8.00 | 7.99 | 7.97 | 7.96 | 7.94 | 7.93 |
| 26 | 7.94 | 7.92 | 7.91 | 7.89 | 7.88 | 7.86 | 7.85 | 7.83 | 7.82 | 7.80 |
| 27 | 7.79 | 7.77 | 7.76 | 7.75 | 7.73 | 7.72 | 7.70 | 7.69 | 7.67 | 7.66 |
| 28 | 7.64 | 7.63 | 7.62 | 7.60 | 7.59 | 7.57 | 7.56 | 7.54 | 7.53 | 7.52 |
| 29 | 7.50 | 7.49 | 7.47 | 7.46 | 7.44 | 7.43 | 7.42 | 7.40 | 7.39 | 7.38 |
| 30 | 7.36 | 7.35 | 7.33 | 7.32 | 7.31 | 7.29 | 7.28 | 7.26 | 7.25 | 7.24 |

**TABLE D1 (cont.). KENTUCKY DIVISION OF WATER SATURATION CONCENTRATION OF DISSOLVED OXYGEN BY ELEVATION**

| | ELEVATION = 500 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **TEMP** | **X.1** | **X.2** | **X.3** | **X.4** | **X.5** | **X.6** | **X.7** | **X.8** | **X.9** | **X.10** |
| 0 | 14.38 | 14.34 | 14.30 | 14.26 | 14.22 | 14.18 | 14.14 | 14.10 | 14.06 | 14.02 |
| 1 | 13.98 | 13.94 | 13.90 | 13.87 | 13.83 | 13.79 | 13.75 | 13.72 | 13.68 | 13.64 |
| 2 | 13.60 | 13.57 | 13.53 | 13.49 | 13.46 | 13.42 | 13.38 | 13.35 | 13.31 | 13.27 |
| 3 | 13.24 | 13.20 | 13.17 | 13.13 | 13.10 | 13.06 | 13.03 | 12.99 | 12.96 | 12.92 |
| 4 | 12.89 | 12.86 | 12.82 | 12.79 | 12.75 | 12.72 | 12.69 | 12.65 | 12.62 | 12.59 |
| 5 | 12.55 | 12.52 | 12.49 | 12.46 | 12.42 | 12.39 | 12.36 | 12.33 | 12.29 | 12.26 |
| 6 | 12.23 | 12.20 | 12.17 | 12.14 | 12.11 | 12.07 | 12.04 | 12.01 | 11.98 | 11.95 |
| 7 | 11.92 | 11.89 | 11.86 | 11.83 | 11.80 | 11.77 | 11.74 | 11.71 | 11.68 | 11.65 |
| 8 | 11.62 | 11.60 | 11.57 | 11.54 | 11.51 | 11.48 | 11.45 | 11.42 | 11.40 | 11.37 |
| 9 | 11.34 | 11.31 | 11.28 | 11.26 | 11.23 | 11.20 | 11.17 | 11.15 | 11.12 | 11.09 |
| 10 | 11.07 | 11.04 | 11.01 | 10.99 | 10.96 | 10.93 | 10.91 | 10.88 | 10.85 | 10.83 |
| 11 | 10.80 | 10.78 | 10.75 | 10.73 | 10.70 | 10.68 | 10.65 | 10.63 | 10.60 | 10.58 |
| 12 | 10.55 | 10.53 | 10.50 | 10.48 | 10.45 | 10.43 | 10.40 | 10.38 | 10.36 | 10.33 |
| 13 | 10.31 | 10.29 | 10.26 | 10.24 | 10.22 | 10.19 | 10.17 | 10.15 | 10.12 | 10.10 |
| 14 | 10.08 | 10.05 | 10.03 | 10.01 | 9.99 | 9.96 | 9.94 | 9.92 | 9.90 | 9.88 |
| 15 | 9.85 | 9.83 | 9.81 | 9.79 | 9.77 | 9.75 | 9.73 | 9.70 | 9.68 | 9.66 |
| 16 | 9.64 | 9.62 | 9.60 | 9.58 | 9.56 | 9.54 | 9.52 | 9.50 | 9.48 | 9.45 |
| 17 | 9.43 | 9.41 | 9.39 | 9.37 | 9.35 | 9.33 | 9.32 | 9.30 | 9.28 | 9.26 |
| 18 | 9.24 | 9.22 | 9.20 | 9.18 | 9.16 | 9.14 | 9.12 | 9.10 | 9.08 | 9.07 |
| 19 | 9.05 | 9.03 | 9.01 | 8.99 | 8.97 | 8.95 | 8.94 | 8.92 | 8.90 | 8.88 |
| 20 | 8.86 | 8.84 | 8.83 | 8.81 | 8.79 | 8.77 | 8.76 | 8.74 | 8.72 | 8.70 |
| 21 | 8.69 | 8.67 | 8.65 | 8.63 | 8.62 | 8.60 | 8.58 | 8.57 | 8.55 | 8.53 |
| 22 | 8.52 | 8.50 | 8.48 | 8.46 | 8.45 | 8.43 | 8.42 | 8.40 | 8.38 | 8.37 |
| 23 | 8.35 | 8.33 | 8.32 | 8.30 | 8.29 | 8.27 | 8.25 | 8.24 | 8.22 | 8.21 |
| 24 | 8.19 | 8.17 | 8.16 | 8.14 | 8.13 | 8.11 | 8.10 | 8.08 | 8.06 | 8.05 |
| 25 | 8.03 | 8.02 | 8.00 | 7.99 | 7.97 | 7.96 | 7.94 | 7.93 | 7.91 | 7.90 |
| 26 | 7.91 | 7.90 | 7.88 | 7.87 | 7.85 | 7.84 | 7.82 | 7.81 | 7.79 | 7.78 |
| 27 | 7.76 | 7.75 | 7.73 | 7.72 | 7.70 | 7.69 | 7.67 | 7.66 | 7.65 | 7.63 |
| 28 | 7.62 | 7.60 | 7.59 | 7.57 | 7.56 | 7.55 | 7.53 | 7.52 | 7.50 | 7.49 |
| 29 | 7.48 | 7.46 | 7.45 | 7.43 | 7.42 | 7.41 | 7.39 | 7.38 | 7.36 | 7.35 |
| 30 | 7.34 | 7.32 | 7.31 | 7.29 | 7.28 | 7.27 | 7.25 | 7.24 | 7.23 | 7.21 |

**TABLE D1 (cont.). KENTUCKY DIVISION OF WATER SATURATION CONCENTRATION OF DISSOLVED OXYGEN BY ELEVATION**

| | ELEVATION = 600 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **TEMP** | **X.1** | **X.2** | **X.3** | **X.4** | **X.5** | **X.6** | **X.7** | **X.8** | **X.9** | **X.10** |
| 0 | 14.32 | 14.28 | 14.24 | 14.20 | 14.16 | 14.12 | 14.08 | 14.04 | 14.01 | 13.97 |
| 1 | 13.93 | 13.89 | 13.85 | 13.81 | 13.78 | 13.74 | 13.70 | 13.66 | 13.63 | 13.59 |
| 2 | 13.55 | 13.51 | 13.48 | 13.44 | 13.40 | 13.37 | 13.33 | 13.30 | 13.26 | 13.22 |
| 3 | 13.19 | 13.15 | 13.12 | 13.08 | 13.05 | 13.01 | 12.98 | 12.94 | 12.91 | 12.88 |
| 4 | 12.84 | 12.81 | 12.77 | 12.74 | 12.71 | 12.67 | 12.64 | 12.61 | 12.57 | 12.54 |
| 5 | 12.51 | 12.47 | 12.44 | 12.41 | 12.38 | 12.34 | 12.31 | 12.28 | 12.25 | 12.22 |
| 6 | 12.19 | 12.15 | 12.12 | 12.09 | 12.06 | 12.03 | 12.00 | 11.97 | 11.94 | 11.91 |
| 7 | 11.88 | 11.85 | 11.82 | 11.79 | 11.76 | 11.73 | 11.70 | 11.67 | 11.64 | 11.61 |
| 8 | 11.58 | 11.55 | 11.52 | 11.50 | 11.47 | 11.44 | 11.41 | 11.38 | 11.35 | 11.33 |
| 9 | 11.30 | 11.27 | 11.24 | 11.21 | 11.19 | 11.16 | 11.13 | 11.11 | 11.08 | 11.05 |
| 10 | 11.03 | 11.00 | 10.97 | 10.95 | 10.92 | 10.89 | 10.87 | 10.84 | 10.82 | 10.79 |
| 11 | 10.76 | 10.74 | 10.71 | 10.69 | 10.66 | 10.64 | 10.61 | 10.59 | 10.56 | 10.54 |
| 12 | 10.51 | 10.49 | 10.46 | 10.44 | 10.42 | 10.39 | 10.37 | 10.34 | 10.32 | 10.30 |
| 13 | 10.27 | 10.25 | 10.22 | 10.20 | 10.18 | 10.16 | 10.13 | 10.11 | 10.09 | 10.06 |
| 14 | 10.04 | 10.02 | 10.00 | 9.97 | 9.95 | 9.93 | 9.91 | 9.88 | 9.86 | 9.84 |
| 15 | 9.82 | 9.80 | 9.78 | 9.75 | 9.73 | 9.71 | 9.69 | 9.67 | 9.65 | 9.63 |
| 16 | 9.61 | 9.58 | 9.56 | 9.54 | 9.52 | 9.50 | 9.48 | 9.46 | 9.44 | 9.42 |
| 17 | 9.40 | 9.38 | 9.36 | 9.34 | 9.32 | 9.30 | 9.28 | 9.26 | 9.24 | 9.22 |
| 18 | 9.20 | 9.18 | 9.17 | 9.15 | 9.13 | 9.11 | 9.09 | 9.07 | 9.05 | 9.03 |
| 19 | 9.01 | 9.00 | 8.98 | 8.96 | 8.94 | 8.92 | 8.90 | 8.89 | 8.87 | 8.85 |
| 20 | 8.83 | 8.81 | 8.80 | 8.78 | 8.76 | 8.75 | 8.73 | 8.71 | 8.69 | 8.67 |
| 21 | 8.66 | 8.64 | 8.62 | 8.60 | 8.59 | 8.57 | 8.55 | 8.54 | 8.52 | 8.50 |
| 22 | 8.49 | 8.47 | 8.45 | 8.44 | 8.42 | 8.40 | 8.39 | 8.37 | 8.35 | 8.34 |
| 23 | 8.32 | 8.30 | 8.29 | 8.27 | 8.26 | 8.24 | 8.22 | 8.21 | 8.19 | 8.18 |
| 24 | 8.16 | 8.15 | 8.13 | 8.11 | 8.10 | 8.08 | 8.07 | 8.05 | 8.04 | 8.02 |
| 25 | 8.01 | 7.99 | 7.98 | 7.96 | 7.95 | 7.93 | 7.92 | 7.90 | 7.89 | 7.87 |
| 26 | 7.88 | 7.87 | 7.85 | 7.84 | 7.82 | 7.81 | 7.79 | 7.78 | 7.76 | 7.75 |
| 27 | 7.74 | 7.72 | 7.71 | 7.69 | 7.68 | 7.66 | 7.65 | 7.63 | 7.62 | 7.61 |
| 28 | 7.59 | 7.58 | 7.56 | 7.55 | 7.53 | 7.52 | 7.51 | 7.49 | 7.48 | 7.46 |
| 29 | 7.45 | 7.44 | 7.42 | 7.41 | 7.39 | 7.38 | 7.37 | 7.35 | 7.34 | 7.32 |
| 30 | 7.31 | 7.30 | 7.28 | 7.27 | 7.26 | 7.24 | 7.23 | 7.21 | 7.20 | 7.19 |

**TABLE D1 (cont.). KENTUCKY DIVISION OF WATER SATURATION CONCENTRATION OF DISSOLVED OXYGEN BY ELEVATION**

| | ELEVATION = 700 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **TEMP** | **X1** | **X2** | **X3** | **X4** | **X5** | **X6** | **X7** | **X8** | **X9** | **X10** |
| 0 | 14.27 | 14.23 | 14.19 | 14.15 | 14.11 | 14.07 | 14.03 | 13.99 | 13.95 | 13.91 |
| 1 | 13.88 | 13.84 | 13.80 | 13.76 | 13.72 | 13.69 | 13.65 | 13.61 | 13.57 | 13.54 |
| 2 | 13.50 | 13.46 | 13.43 | 13.39 | 13.35 | 13.32 | 13.28 | 13.25 | 13.21 | 13.18 |
| 3 | 13.14 | 13.10 | 13.07 | 13.03 | 13.00 | 12.96 | 12.93 | 12.90 | 12.86 | 12.83 |
| 4 | 12.79 | 12.76 | 12.73 | 12.69 | 12.66 | 12.62 | 12.59 | 12.56 | 12.53 | 12.49 |
| 5 | 12.46 | 12.43 | 12.40 | 12.36 | 12.33 | 12.30 | 12.27 | 12.23 | 12.20 | 12.17 |
| 6 | 12.14 | 12.11 | 12.08 | 12.05 | 12.02 | 11.99 | 11.95 | 11.92 | 11.89 | 11.86 |
| 7 | 11.83 | 11.80 | 11.77 | 11.74 | 11.71 | 11.68 | 11.66 | 11.63 | 11.60 | 11.57 |
| 8 | 11.54 | 11.51 | 11.48 | 11.45 | 11.42 | 11.40 | 11.37 | 11.34 | 11.31 | 11.28 |
| 9 | 11.26 | 11.23 | 11.20 | 11.17 | 11.15 | 11.12 | 11.09 | 11.06 | 11.04 | 11.01 |
| 10 | 10.98 | 10.96 | 10.93 | 10.91 | 10.88 | 10.85 | 10.83 | 10.80 | 10.78 | 10.75 |
| 11 | 10.72 | 10.70 | 10.67 | 10.65 | 10.62 | 10.60 | 10.57 | 10.55 | 10.52 | 10.50 |
| 12 | 10.47 | 10.45 | 10.43 | 10.40 | 10.38 | 10.35 | 10.33 | 10.31 | 10.28 | 10.26 |
| 13 | 10.23 | 10.21 | 10.19 | 10.16 | 10.14 | 10.12 | 10.10 | 10.07 | 10.05 | 10.03 |
| 14 | 10.00 | 9.98 | 9.96 | 9.94 | 9.92 | 9.89 | 9.87 | 9.85 | 9.83 | 9.81 |
| 15 | 9.78 | 9.76 | 9.74 | 9.72 | 9.70 | 9.68 | 9.66 | 9.63 | 9.61 | 9.59 |
| 16 | 9.57 | 9.55 | 9.53 | 9.51 | 9.49 | 9.47 | 9.45 | 9.43 | 9.41 | 9.39 |
| 17 | 9.37 | 9.35 | 9.33 | 9.31 | 9.29 | 9.27 | 9.25 | 9.23 | 9.21 | 9.19 |
| 18 | 9.17 | 9.15 | 9.13 | 9.11 | 9.09 | 9.08 | 9.06 | 9.04 | 9.02 | 9.00 |
| 19 | 8.98 | 8.96 | 8.95 | 8.93 | 8.91 | 8.89 | 8.87 | 8.85 | 8.84 | 8.82 |
| 20 | 8.80 | 8.78 | 8.76 | 8.75 | 8.73 | 8.71 | 8.69 | 8.68 | 8.66 | 8.64 |
| 21 | 8.62 | 8.61 | 8.59 | 8.57 | 8.56 | 8.54 | 8.52 | 8.51 | 8.49 | 8.47 |
| 22 | 8.46 | 8.44 | 8.42 | 8.41 | 8.39 | 8.37 | 8.36 | 8.34 | 8.32 | 8.31 |
| 23 | 8.29 | 8.28 | 8.26 | 8.24 | 8.23 | 8.21 | 8.20 | 8.18 | 8.16 | 8.15 |
| 24 | 8.13 | 8.12 | 8.10 | 8.09 | 8.07 | 8.05 | 8.04 | 8.02 | 8.01 | 7.99 |
| 25 | 7.98 | 7.96 | 7.95 | 7.93 | 7.92 | 7.90 | 7.89 | 7.87 | 7.86 | 7.84 |
| 26 | 7.86 | 7.84 | 7.83 | 7.81 | 7.80 | 7.78 | 7.77 | 7.75 | 7.74 | 7.72 |
| 27 | 7.71 | 7.69 | 7.68 | 7.67 | 7.65 | 7.64 | 7.62 | 7.61 | 7.59 | 7.58 |
| 28 | 7.56 | 7.55 | 7.54 | 7.52 | 7.51 | 7.49 | 7.48 | 7.47 | 7.45 | 7.44 |
| 29 | 7.42 | 7.41 | 7.40 | 7.38 | 7.37 | 7.35 | 7.34 | 7.33 | 7.31 | 7.30 |
| 30 | 7.29 | 7.27 | 7.26 | 7.24 | 7.23 | 7.22 | 7.20 | 7.19 | 7.18 | 7.16 |

**TABLE D1 (cont.). KENTUCKY DIVISION OF WATER SATURATION CONCENTRATION OF DISSOLVED OXYGEN BY ELEVATION**

**ELEVATION = 800**

| TEMP | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 14.21 | 14.17 | 14.13 | 14.09 | 14.05 | 14.02 | 13.98 | 13.94 | 13.90 | 13.86 |
| 1 | 13.82 | 13.79 | 13.75 | 13.71 | 13.67 | 13.63 | 13.60 | 13.56 | 13.52 | 13.49 |
| 2 | 13.45 | 13.41 | 13.38 | 13.34 | 13.30 | 13.37 | 13.23 | 13.20 | 13.16 | 13.13 |
| 3 | 13.09 | 13.06 | 13.02 | 12.99 | 12.95 | 12.92 | 12.88 | 12.85 | 12.81 | 12.78 |
| 4 | 12.75 | 12.71 | 12.68 | 12.64 | 12.61 | 12.58 | 12.54 | 12.51 | 12.48 | 12.45 |
| 5 | 12.41 | 12.38 | 12.35 | 12.32 | 12.28 | 12.25 | 12.22 | 12.19 | 12.16 | 12.13 |
| 6 | 12.10 | 12.06 | 12.03 | 12.00 | 11.97 | 11.94 | 11.91 | 11.88 | 11.85 | 11.82 |
| 7 | 11.79 | 11.76 | 11.73 | 11.70 | 11.67 | 11.64 | 11.61 | 11.58 | 11.55 | 11.52 |
| 8 | 11.50 | 11.47 | 11.44 | 11.41 | 11.38 | 11.35 | 11.33 | 11.30 | 11.27 | 11.24 |
| 9 | 11.21 | 11.19 | 11.16 | 11.13 | 11.11 | 11.08 | 11.05 | 11.02 | 11.00 | 10.97 |
| 10 | 10.94 | 10.92 | 10.89 | 10.87 | 10.84 | 10.81 | 10.79 | 10.76 | 10.74 | 10.71 |
| 11 | 10.69 | 10.66 | 10.63 | 10.61 | 10.58 | 10.56 | 10.53 | 10.51 | 10.49 | 10.46 |
| 12 | 10.44 | 10.41 | 10.39 | 10.36 | 10.34 | 10.32 | 10.29 | 10.27 | 10.24 | 10.22 |
| 13 | 10.22 | 10.17 | 10.15 | 10.13 | 10.10 | 10.08 | 10.06 | 10.04 | 10.01 | 9.99 |
| 14 | 9.97 | 9.95 | 9.92 | 9.90 | 9.88 | 9.86 | 9.84 | 9.81 | 9.79 | 9.77 |
| 15 | 9.75 | 9.73 | 9.71 | 9.68 | 9.66 | 9.64 | 9.62 | 9.60 | 9.58 | 9.56 |
| 16 | 9.54 | 9.52 | 9.50 | 9.48 | 9.45 | 9.43 | 9.41 | 9.39 | 9.37 | 9.35 |
| 17 | 9.33 | 9.31 | 9.29 | 9.27 | 9.25 | 9.24 | 9.22 | 9.20 | 9.18 | 9.16 |
| 18 | 9.14 | 9.12 | 9.10 | 9.08 | 9.06 | 9.04 | 9.02 | 9.01 | 8.99 | 8.97 |
| 19 | 8.95 | 8.93 | 8.91 | 8.90 | 8.88 | 8.86 | 8.84 | 8.82 | 8.80 | 8.79 |
| 20 | 8.77 | 8.75 | 8.73 | 8.72 | 8.70 | 8.68 | 8.66 | 8.65 | 8.63 | 8.61 |
| 21 | 8.59 | 8.58 | 8.56 | 8.54 | 8.53 | 8.51 | 8.49 | 8.48 | 8.46 | 8.44 |
| 22 | 8.43 | 8.41 | 8.39 | 8.38 | 8.36 | 8.34 | 8.33 | 8.31 | 8.29 | 8.28 |
| 23 | 8.26 | 8.25 | 8.23 | 8.21 | 8.20 | 8.18 | 8.17 | 8.15 | 8.14 | 8.12 |
| 24 | 8.10 | 8.09 | 8.07 | 8.06 | 8.04 | 8.03 | 8.01 | 8.00 | 7.98 | 7.97 |
| 25 | 7.95 | 7.94 | 7.92 | 7.91 | 7.89 | 7.88 | 7.86 | 7.85 | 7.83 | 7.82 |
| 26 | 7.83 | 7.81 | 7.80 | 7.78 | 7.77 | 7.75 | 7.74 | 7.73 | 7.71 | 7.70 |
| 27 | 7.68 | 7.67 | 7.65 | 7.64 | 7.62 | 7.61 | 7.60 | 7.58 | 7.57 | 7.55 |
| 28 | 7.54 | 7.52 | 7.51 | 7.50 | 7.48 | 7.47 | 7.45 | 7.44 | 7.43 | 7.41 |
| 29 | 7.40 | 7.38 | 7.37 | 7.36 | 7.34 | 7.33 | 7.32 | 7.30 | 7.29 | 7.27 |
| 30 | 7.26 | 7.25 | 7.23 | 7.22 | 7.21 | 7.19 | 7.18 | 7.17 | 7.15 | 7.14 |

**TABLE D1 (cont.). KENTUCKY DIVISION OF WATER SATURATION CONCENTRATION OF DISSOLVED OXYGEN BY ELEVATION**

| | ELEVATION = 900 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **TEMP** | **X1** | **X2** | **X3** | **X4** | **X5** | **X6** | **X7** | **X8** | **X9** | **X10** |
| 0 | 14.16 | 14.12 | 14.08 | 14.04 | 14.00 | 13.96 | 13.92 | 13.89 | 13.85 | 13.81 |
| 1 | 13.77 | 13.73 | 13.70 | 13.66 | 13.62 | 13.58 | 13.55 | 13.51 | 13.47 | 13.44 |
| 2 | 13.40 | 13.36 | 13.33 | 13.29 | 13.25 | 13.22 | 13.18 | 13.15 | 13.11 | 13.08 |
| 3 | 13.04 | 13.01 | 12.97 | 12.94 | 12.90 | 12.87 | 12.83 | 12.80 | 12.76 | 12.73 |
| 4 | 12.70 | 12.66 | 12.63 | 12.60 | 12.56 | 12.53 | 12.50 | 12.46 | 12.43 | 12.40 |
| 5 | 12.37 | 12.33 | 12.30 | 12.27 | 12.24 | 12.21 | 12.18 | 12.14 | 12.11 | 12.08 |
| 6 | 12.05 | 12.02 | 11.99 | 11.96 | 11.93 | 11.90 | 11.87 | 11.84 | 11.81 | 11.78 |
| 7 | 11.75 | 11.72 | 11.69 | 11.66 | 11.63 | 11.60 | 11.57 | 11.54 | 11.51 | 11.48 |
| 8 | 11.45 | 11.43 | 11.40 | 11.37 | 11.34 | 11.31 | 11.28 | 11.26 | 11.23 | 11.20 |
| 9 | 11.17 | 11.15 | 11.12 | 11.09 | 11.06 | 11.04 | 11.01 | 10.98 | 10.96 | 10.93 |
| 10 | 10.90 | 10.88 | 10.85 | 10.83 | 10.80 | 10.77 | 10.75 | 10.72 | 10.70 | 10.67 |
| 11 | 10.65 | 10.62 | 10.60 | 10.57 | 10.55 | 10.52 | 10.50 | 10.47 | 10.45 | 10.42 |
| 12 | 10.40 | 10.37 | 10.35 | 10.33 | 10.30 | 10.28 | 10.25 | 10.23 | 10.21 | 10.18 |
| 13 | 10.16 | 10.14 | 10.11 | 10.09 | 10.07 | 10.05 | 10.02 | 10.00 | 9.98 | 9.95 |
| 14 | 9.93 | 9.91 | 9.89 | 9.87 | 9.84 | 9.82 | 9.80 | 9.78 | 9.76 | 9.73 |
| 15 | 9.71 | 9.69 | 9.67 | 9.65 | 9.63 | 9.61 | 9.59 | 9.56 | 9.54 | 9.52 |
| 16 | 9.50 | 9.48 | 9.46 | 9.44 | 9.42 | 9.40 | 9.38 | 9.36 | 9.34 | 9.32 |
| 17 | 9.30 | 9.28 | 9.26 | 9.24 | 9.22 | 9.20 | 9.18 | 9.16 | 9.14 | 9.12 |
| 18 | 9.11 | 9.09 | 9.07 | 9.05 | 9.03 | 9.01 | 8.99 | 8.97 | 8.96 | 8.94 |
| 19 | 8.92 | 8.90 | 8.88 | 8.86 | 8.85 | 8.83 | 8.81 | 8.79 | 8.77 | 8.76 |
| 20 | 8.74 | 8.72 | 8.70 | 8.69 | 8.67 | 8.65 | 8.63 | 8.62 | 8.60 | 8.58 |
| 21 | 8.56 | 8.55 | 8.53 | 8.51 | 8.50 | 8.48 | 8.46 | 8.45 | 8.43 | 8.41 |
| 22 | 8.40 | 8.38 | 8.36 | 8.35 | 8.33 | 8.31 | 8.30 | 8.28 | 8.27 | 8.25 |
| 23 | 8.23 | 8.22 | 8.20 | 8.19 | 8.17 | 8.15 | 8.14 | 8.12 | 8.11 | 8.09 |
| 24 | 8.08 | 8.06 | 8.04 | 8.03 | 8.01 | 8.00 | 7.98 | 7.97 | 7.95 | 7.94 |
| 25 | 7.92 | 7.91 | 7.89 | 7.88 | 7.86 | 7.85 | 7.83 | 7.82 | 7.80 | 7.79 |
| 26 | 7.80 | 7.79 | 7.77 | 7.76 | 7.74 | 7.73 | 7.71 | 7.70 | 7.68 | 7.67 |
| 27 | 7.66 | 7.64 | 7.63 | 7.61 | 7.60 | 7.58 | 7.57 | 7.56 | 7.54 | 7.53 |
| 28 | 7.51 | 7.50 | 7.48 | 7.47 | 7.46 | 7.44 | 7.43 | 7.41 | 7.40 | 7.39 |
| 29 | 7.37 | 7.36 | 7.35 | 7.33 | 7.32 | 7.30 | 7.29 | 7.28 | 7.26 | 7.25 |
| 30 | 7.24 | 7.22 | 7.21 | 7.19 | 7.18 | 7.17 | 7.15 | 7.14 | 7.13 | 7.11 |

**TABLE D1 (cont.), KENTUCKY DIVISION OF WATER SATURATION CONCENTRATION OF DISSOLVED OXYGEN BY ELEVATION**

| | | | | ELEVATION = 1000 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **TEMP** | **X1** | **X2** | **X3** | **X4** | **X5** | **X6** | **X7** | **X8** | **X9** | **X10** |
| 0 | 14.10 | 14.06 | 14.03 | 13.99 | 13.95 | 13.91 | 13.87 | 13.83 | 13.79 | 13.76 |
| 1 | 13.72 | 13.68 | 13.64 | 13.61 | 13.57 | 13.53 | 13.49 | 13.46 | 13.42 | 13.38 |
| 2 | 13.35 | 13.31 | 13.28 | 13.24 | 13.20 | 13.17 | 13.13 | 13.10 | 13.06 | 13.03 |
| 3 | 12.99 | 12.96 | 12.92 | 12.89 | 12.85 | 12.82 | 12.78 | 12.75 | 12.72 | 12.68 |
| 4 | 12.65 | 12.62 | 12.58 | 12.55 | 12.52 | 12.48 | 12.45 | 12.42 | 12.39 | 12.35 |
| 5 | 12.32 | 12.29 | 12.26 | 12.22 | 12.19 | 12.16 | 12.13 | 12.10 | 12.07 | 12.04 |
| 6 | 12.01 | 11.97 | 11.94 | 11.91 | 11.88 | 11.85 | 11.82 | 11.79 | 11.76 | 11.73 |
| 7 | 11.70 | 11.67 | 11.64 | 11.61 | 11.58 | 11.56 | 11.53 | 11.50 | 11.47 | 11.44 |
| 8 | 11.41 | 11.38 | 11.35 | 11.33 | 11.30 | 11.27 | 11.24 | 11.21 | 11.19 | 11.16 |
| 9 | 11.13 | 11.10 | 11.08 | 11.05 | 11.02 | 11.00 | 10.97 | 10.94 | 10.92 | 10.89 |
| 10 | 10.86 | 10.84 | 10.81 | 10.79 | 10.76 | 10.73 | 10.71 | 10.68 | 10.66 | 10.63 |
| 11 | 10.61 | 10.58 | 10.56 | 10.53 | 10.51 | 10.48 | 10.46 | 10.43 | 10.41 | 10.38 |
| 12 | 10.36 | 10.34 | 10.31 | 10.29 | 10.26 | 10.24 | 10.22 | 10.19 | 10.17 | 10.15 |
| 13 | 10.12 | 10.10 | 10.08 | 10.05 | 10.03 | 10.01 | 9.99 | 9.96 | 9.94 | 9.92 |
| 14 | 9.90 | 9.87 | 9.85 | 9.83 | 9.81 | 9.79 | 9.76 | 9.74 | 9.72 | 9.70 |
| 15 | 9.68 | 9.66 | 9.64 | 9.61 | 9.59 | 9.57 | 9.55 | 9.53 | 9.51 | 9.49 |
| 16 | 9.47 | 9.45 | 9.43 | 9.41 | 9.39 | 9.37 | 9.35 | 9.33 | 9.31 | 9.29 |
| 17 | 9.27 | 9.25 | 9.23 | 9.21 | 9.19 | 9.17 | 9.15 | 9.13 | 9.11 | 9.09 |
| 18 | 9.07 | 9.05 | 9.04 | 9.02 | 9.00 | 8.98 | 8.96 | 8.94 | 8.92 | 8.90 |
| 19 | 8.89 | 8.87 | 8.85 | 8.83 | 8.81 | 8.80 | 8.78 | 8.76 | 8.74 | 8.72 |
| 20 | 8.71 | 8.69 | 8.67 | 8.65 | 8.64 | 8.62 | 8.60 | 8.58 | 8.57 | 8.55 |
| 21 | 8.53 | 8.52 | 8.50 | 8.48 | 8.47 | 8.45 | 8.43 | 8.42 | 8.40 | 8.38 |
| 22 | 8.37 | 8.35 | 8.33 | 8.32 | 8.30 | 8.28 | 8.27 | 8.25 | 8.24 | 8.22 |
| 23 | 8.20 | 8.19 | 8.17 | 8.16 | 8.14 | 8.13 | 8.11 | 8.09 | 8.08 | 8.06 |
| 24 | 8.05 | 8.03 | 8.02 | 8.00 | 7.99 | 7.97 | 7.96 | 7.94 | 7.93 | 7.91 |
| 25 | 7.90 | 7.88 | 7.87 | 7.85 | 7.84 | 7.82 | 7.81 | 7.79 | 7.78 | 7.76 |
| 26 | 7.77 | 7.76 | 7.74 | 7.73 | 7.72 | 7.70 | 7.69 | 7.67 | 7.66 | 7.64 |
| 27 | 7.63 | 7.61 | 7.60 | 7.59 | 7.57 | 7.56 | 7.54 | 7.53 | 7.51 | 7.50 |
| 28 | 7.49 | 7.47 | 7.46 | 7.44 | 7.43 | 7.42 | 7.40 | 7.39 | 7.38 | 7.36 |
| 29 | 7.35 | 7.33 | 7.32 | 7.31 | 7.29 | 7.28 | 7.27 | 7.25 | 7.24 | 7.22 |
| 30 | 7.21 | 7.20 | 7.18 | 7.17 | 7.16 | 7.14 | 7.13 | 7.12 | 7.10 | 7.09 |

D-2. [1]Solubility of oxygen in pure water at different temperatures.

| TEMP | mg/L | TEMP | mg/L | TEMP | mg/L |
|---|---|---|---|---|---|
| 0 | 14.16 | 12 | 10.43 | 24 | 8.25 |
| 1 | 13.77 | 13 | 10.2 | 25 | 8.11 |
| 2 | 13.4 | 14 | 9.98 | 26 | 7.99 |
| 3 | 13.05 | 15 | 9.76 | 27 | 7.86 |
| 4 | 12.7 | 16 | 9.56 | 28 | 7.57 |
| 5 | 12.37 | 17 | 9.37 | 29 | 7.64 |
| 6 | 12.06 | 18 | 9.18 | 30 | 7.53 |
| 7 | 11.76 | 19 | 9.01 | 31 | 7.42 |
| 8 | 11.47 | 20 | 8.84 | 32 | 7.32 |
| 9 | 11.19 | 21 | 8.68 | 33 | 7.22 |
| 10 | 10.92 | 22 | 8.53 | 34 | 7.13 |
| 11 | 10.67 | 23 | 8.38 | 35 | 7.04 |

D-3. [2]Correction factor for oxygen saturation at varying altitudes.

| Altitude Correction | | |
|---|---|---|
| (feet) | (meters) | Factor |
| 0 | 0 | 1 |
| 500 | 152 | 0.98 |
| 1000 | 305 | 0.96 |
| 1500 | 457 | 0.95 |
| 2000 | 610 | 0.93 |
| 2500 | 762 | 0.91 |
| 3000 | 914 | 0.89 |
| 3500 | 1067 | 0.88 |
| 4000 | 1219 | 0.86 |
| 4500 | 1372 | 0.84 |

To determine calibration value:
1. Obtain oxygen value form solubility table;
2. Obtain factor from correction table for altitude you are at;
3. Multiply oxygen value by correction factor, calibrate using this value.

[1]*Water quality in warmwater fish ponds*, C.E. Boyd, 1979
[2]British Columbia, Ministry of Environment, Lands, and Parks web site:
http://wlapwww.gov.bc.ca/wat/wq/BCguidelines/do/do-01.htm

# Appendix E
# Kentucky Ambient/Watershed Monitoring Assessment Program Contamination Control

**Kentucky Ambient/Watershed Monitoring Assessment**
**Program Contamination Control**

I. Contamination Problems

A. Preventing ambient water samples from becoming contaminated during the sampling and analytical process is one of the greatest challenges faced in the generation of water quality information. It is imperative that extreme care be taken to avoid contamination when collecting and analyzing ambient water samples.

B. There are numerous routes by which samples may become contaminated. Potential sources of contamination during sampling include: metallic or metal-containing sampling equipment, containers, labware (e.g. talc gloves that contain high levels of zinc), reagents and deionized water; improperly cleaned and stored equipment, labware, reagents; atmospheric inputs such as dirt and dust from vehicular exhaust; cigarette smoke, nearby roads, bridges, wires and poles; and human contact.

II. Contamination Control

A. Philosophy- The philosophy behind contamination control is to ensure that any object or substance that contacts the sample is free from any material that may bias results of variables of concern.

1. The integrity of the results produced cannot be compromised by contamination of samples. Requirements and suggestions for controlling sample contamination are given in this manual.

2. While contamination control is essential, personnel health and safety remain the highest priority. Requirements and suggestions for personnel safety are given in STEP 7 of this manual.

B. Avoiding contamination- The best way to control contamination is to completely avoid exposure of the sample to contaminants in the first place. Avoiding exposure means performing operations in an area known to be free from contamination. Two of the most important factors in avoiding/reducing sample contamination are (1) an awareness of potential sources of contamination and (2) strict attention to work being performed. Therefore, it is imperative that the procedures described in this manual be carried out by well-trained, experienced personnel. Documentation of training should be kept on file and be readily available for review.

C. Minimize exposure- The weighted bottle sampler (WBS) should be sprayed periodically with an epoxy-based paint (provided by Ambient/Watershed

Coordinator). Frequency of spraying depends on the rate at which paint is chipped off as happens during the course of sampling. Spraying is to be performed to eliminate/reduce chance of metal sampler contaminating metals samples.

D. Wear gloves- Sampling personnel must wear clean, powder-free gloves during all operations involving the WBS, samples and blanks. If another object is touched before handling samples, the glove(s) must be changed before handling the samples. Wearing multiple layers of clean gloves will allow the old pair to be quickly stripped with minimal disruption to the work activity. Glove boxes are to be stored in ziplock bags to reduce possibility of contamination. Gloves are to be taken from box only immediately prior to handling of samples. An alternative is to place clean gloves in a ziplock bag, removing gloves prior to sample handling.

E. Use variable-free materials- All equipment used for collecting samples (e.g. sample bottles) must be free of contaminates which could bias analytical results.

F. Construction materials- Only those bottles provided by the Ambient Monitoring Coordinator are to be used in collecting and storing water samples. Bottles designated for metals, mercury and pesticides have been pre-cleaned by the vendor. When vendors are changed, deionized water blanks will be analyzed to ascertain cleanliness.

G. When using the DH-81 sampler- the US D-95 cap and US D-77 nozzle are to be cleaned following STEP 6. When using the DH-81 sampler, an equipment blank must be analyzed for each group of cleaned samplers.

H. Avoid sources of contamination- Avoid contamination by being aware of potential sources and routes of contamination.

I. Contamination by carryover- Contamination may occur when a sample containing low concentrations of variables of interest is processed immediately after a sample containing relatively high concentrations of these variables. To eliminate/reduce the issue of carryover, samples are collected directly into sample bottles. When using the DH-81 sampler, samplers and funnels are to be used at one site only.

J. Contamination by airborne particulate matter- Less obvious substances capable of contaminating samples include airborne particles. Samples may be contaminated by airborne dust, dirt, particulate matter or vapors from vehicular exhaust; cigarette smoke; nearby corroded or rusted bridges, pipes, poles or wires; nearby roads; and even human health. When possible, the sampling activity should occur as far as possible from sources of airborne contamination.

# Appendix F
# Quality Control Design

## Quality Control Design

The primary goal of the Kentucky Ambient/Watershed Monitoring Assessment (KENTUCKY AMBIENT/WATERSHED MONITORING ASSESSMENT) program is to provide legally defensible water quality information. This information is used to assess use support and water quality variable trends in Kentucky's lakes and rivers. To interpret water quality data properly, information is needed to estimate the bias and variability that result from sample collection, sample processing and chemical analysis. Bias is the systematic error inherent in a method and may be either positive or negative. Variability is the degree of random error in repeated measurements of the same quantity.

The objectives in evaluating sampling bias and variability for surface water chemical analyses are to determine the extent to which:

1. Sampling methods and equipment introduce contaminants (positive bias) into water samples.
2. Sample matrix interference or analyte degradation affect the recovery (bias and variability) of organic samples.
3. Sample collection, processing and analysis affect the variability of measured constituent concentrations.

Quality assurance of field measurements is determined through twice yearly meter audits. Quality assurance of surface water chemical data is determined from routine quality control (QC) samples used to meet these objectives and to evaluate potential effects on the interpretation of environmental data. Quality control objectives are listed in Table F-1.

Table F-1. Quality control objectives (RPD, relative percent difference)

| Variable | Accuracy | Precision | Completeness |
|---|---|---|---|
| **Field Measurements:** | | | |
| Water temperature | ±0.5 degrees C | RPD within 20% | 90% |
| Specific conductance | ±5% of meter range | RPD within 20% | 90% |
| PH | ±0.2 SU | RPD within 20% | 90% |
| Dissolved Oxygen | ±5% | RPD within 20% | 90% |
| **Surface water chemical analysis:** | | | |
| Total organic carbon | ±3% of known conc. | RPD within 20% | 90% |
| Suspended sediment | ±3 standard deviations of known conc. | RPD within 20% | 90% |
| Major ions | Same as above | RPD within 20% | 90% |
| Nutrients | Same as above | RPD within 20% | 90% |
| Trace elements | Same as above | RPD within 20% | 90% |
| Pesticides | | RPD within 20% | 90% |

**Field Measurements**

Field meter audits involve the shipping of audit unknowns for specific conductance and pH to all personnel involved in monitoring. Reports of measured unknowns are sent from the field offices to the Ambient Monitoring Coordinator. Once all reports are received, a most probable number is determined based on all received reports. Reported measurements are then evaluated for precision. All field probes in use (Hydrolab) are reported by the manufacturer to have an accuracy of ±0.2 pH units.

**Surface Water Chemical Data**

Two types of QC samples are to be collected. Blanks are used to estimate bias. Replicates are used to estimate variability.

**Field blanks**

A blank is a water sample that is intended to be free of analytes of interest. Blank samples are analyzed to test for bias that could result from contamination of environmental samples by the analytes of interest during any stage of sample collection, processing and analysis. A field blank is prepared in the field and used to demonstrate that: (1) sample collection and processing have not resulted in contamination and (2) sample handling and transport have not introduced contamination. In addition, because the field blank is treated like an environmental sample at the laboratory, it includes potential contamination introduced during laboratory handling and analysis.

Field blanks should be prepared immediately before collecting and processing an environmental sample at a selected site. Use only deionized water from the Division of Environmental Services. Water designated for field blanks will be provided by Ambient Monitoring Coordinator.

1. For mercury field blanks pour ultra pure DIW into the sample bottle. Cap and shake.
2. For dissolved metals field blanks filter 500 ml of ultra pure DIW as outlined in Appendix I.
3. Preserve the samples according to STEP 11.

**Replicate samples**

Replicates are two or more samples collected so that the samples are considered identical in composition. Replicate samples as used in the KENTUCKY AMBIENT/WATERSHED MONITORING ASSESSMENT are concurrent samples. Concurrent replicates are multiple (usually 2) samples collected from an environmental matrix as close as possible to the same location and time. These replicates account for variability introduced by sample collection, processing and analysis.

1. Rinse sample bottles with native stream water.

2. For each variable group specified by the sample plan, collect a pair of replicate concurrent samples.
3. Preserve as outlined in STEP 11.

**Frequency, timing and collection of QC samples**

The minimum number of each type of QC sample required to meet the stated QC objectives is listed in Table F-2.

In order not to overload the DES laboratory, initial collection of field blank and duplicate samples will be gradually introduced. A list of when to make the initial collection will be sent to the regional offices by the Ambient Monitoring Coordinator. Subsequent QC samples should be collected on a yearly basis, determined from the initial sample date. Field blanks can be prepared at any surface water site; however, certain sites should be targeted to test greatest potential risk of contamination. Duplicates should be targeted at sites and times where concentrations of at least some target analytes are expected to exceed detection limits. Surface water samples collected by more than one sampling-team should prepare and submit a field blank and duplicate. The goal is to evaluate each sampling team and set of equipment often enough to ensure that procedures are adequate or that corrective actions are taken.

Table F-2. [1]Collection frequencies for routine quality control samples.

| Constituent or group | Number of QC samples/total number of environmental samples | |
|---|---|---|
| | Field blanks | Duplicates |
| Major ions | 1 per 20 | 1 per 20 |
| Nutrients | 1 per 20 | 1 per 20 |
| Pesticides | 1 per 20 | 1 per 10 |
| Metals (total recoverable) | 1 per 20 | 1 per 15 |
| Metals (dissolved) | 1 per trip | 5% of samples over sample period. |

[1]If number of QC samples for a given sampling year (April through March) is less than number in in Table F-2, collect samples on an annual basis.

# Appendix G
# Chain of Custody

# AMBIENT/ WATERSHED MONITORING
## CHAIN OF CUSTODY
## DIVISION OF WATER

**Sampler ID:** W. Allan Kidd

**REPORT NUMBER: A19 -** 10967 **LABORATORY NUMBER:** 02-4019

**Site Identification** **Collection Date/Time**

Location: Pond River-Sacramento Date: 2002/12/10 Time: 1020 hrs

Station #: PRI012 County Name: McLean

**Field Measurements**

Temp: 1.9 Sp. Cond.: 714 pH: 7.8 D.O.: 11.6 Turbidity: 30.9

Stage height: 418+07' (tapedown) USGS wire-weight USGS Internet

| Matrix Requested Water /Sediment | pH | Container Size, Type | Preservation Method | Variables |
|---|---|---|---|---|
| ✓ | 6.0 | 1 liter, HDPE bottle | Cool to 4 degrees C | Bulk variables |
| ✓ | 2.0 | 1 liter, HDPE bottle | Cool to 4 degrees C, H2SO4 < pH 2.0 | Nutrients |
| ✓ | 2.0 | 1 liter. HDPE bottle | Cool to 4 degrees C, HNO3 < pH 2.0 | Metals |
| ✓ | 1.0 | 1 liter, amber glass bottle | 5 ml HCL, cool to 4 degrees C | Low level Hg |
| | | 1 liter, amber glass bottle | Cool to 4 degrees C | N/P Pesticides Method 507/ 508 |
| | | 1 liter, amber glass bottle | Cool to 4 degrees C | Herbicides Method 515.1 |
| | | 120 ml, amber glass bottle | Cool to 4 degrees C, 4 ml monochloracetic acid | Carbamates Method 531.1 |
| | | 120 ml, amber glass bottle | Cool to 4 degrees C | Glyphosate (Roundup) |
| | | 120 ml, coliform sample bottle/ Whirlpak | Cool to 4 degrees C | Fecal Coliform |

- HDPE – high density polyethylene plastic
- Acid Lot Numbers: Sulfuric SA015709O Nitric NA015708O Hydrochloric HA204311O

**Signatures:**

Relinquished by: [signature] Date: 12/10/02 Time: 1400

UPS Received by: Jennifer Clark Date: 12-11-02 Time: 1100

Relinquished by: _____ Date: _____ Time: _____

Received by: _____ Date: _____ Time: _____

0.2°

## FIELD OBSERVATIONS

**Sampling location:** Bridge ✓; In-stream (wading) _____; Boat _____;
Lat/long: _____

**Flow conditions:**

Dry _____ Low _____ Normal _____ Above Normal ✓ Flood _____

**Hydrologic condition** (if possible to determine):

Stable ✓ Falling _____ Rising _____ Peak _____

**Weather (at time of sampling):**

Cloud cover: Sunny _____ Partly Cloudy _____ Overcast ✓

Air temperature: Freezing (<32 degrees) _____
Cold (above 32 degrees to 50 degrees) ✓
Mild (above 50 degrees to 80 degrees) _____
Hot (above 80 degrees to 95 degrees) _____
Very hot (>95 degrees) _____

Precipitation: Fog _____ Drizzle _____ Rain ✓ Snow/sleet _____

**Weather in past 24 hours:**

Storm (heavy rain) _____ Rain (steady rain) _____ Showers (intermittent rain) _____
Overcast ✓ Clear/Sunny _____

**Stream mixing:** Excellent ✓ Good _____ Fair _____ Poor _____

If mixing fair or poor, why _____

**Stream color:** brown ✓ green _____ blue _____ clear _____ other (explain) _____

**Observations:** Floating woody debris _____ Floating garbage _____ Algal mats _____
Fish kill _____ Detergent suds _____ Odor _____ Oil/Grease _____

**Stream shading** (evaluate in summer months):
fully canopied _____ partially canopied _____ not shaded _____

**General observations:**

# Apppendix H
# Lake Data Sheet

| STATION NUMBER: CLN | | | LAKE STATION NAME: | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| DATE: ___/___/ yr mo day | | | TIME ___: 24 hours | | SITE COLLECTED: | | | | |
| Field Data | | | Unit | Code | Value | | | | |
| Secchi Disk Transparency | | | Meters | 00078 | | Secchi Disk: (Ft.) | | | |
| Depth (Maximum) | | | Meters | 00205 | | | | | |
| Euphotic Zone Depth | | | Meters | 00204 | | Foot Candles: | | | |
| Depth 00098 | Temp 00010 | pH 00400 | DO 00299 | Cond 00094 | Depth 00098 | Temp 00010 | pH 00400 | DO 00299 | Cond 00094 |
| Surface | | | | | 16m | | | | |
| 1m | | | | | 17m | | | | |
| 2m | | | | | 18m | | | | |
| 3m | | | | | 19m | | | | |
| 4m | | | | | 20m | | | | |
| 5m | | | | | 21m | | | | |
| 6m | | | | | 22m | | | | |
| 7m | | | | | 23m | | | | |
| 8m | | | | | 24m | | | | |
| 9m | | | | | 25m | | | | |
| 10m | | | | | 30m | | | | |
| 11m | | | | | 35m | | | | |
| 12m | | | | | 40m | | | | |
| 13m | | | | | 45m | | | | |
| 14m | | | | | 50m | | | | |
| 15m | | | | | 55m | | | | |

Foot Notes -

STATION NUMBER CLN_____DATE__/__/__/TIME__:__
yr mon day 24 hr.

Euphotic Zone:

Depth in Meters

| Laboratory Data | Unit | Code | Remark | | | |
|---|---|---|---|---|---|---|
| $NH_3$-N | mg/l | 00610 | X | | | |
| $No_2$+$NO_3$-N | mg/l | 00630 | X | | | |
| TKN | mg/l | 00625 | X | | | |
| Phosphorus, total | mg/l | 00665 | X | | | |
| Phosphorus, dissolved | mg/l | 00666 | X | | | |
| Phosphorus, ortho | mg/l | 00671 | X | | | |
| Chlorophyll a (plankton) | mg/l | 32209 | X | | | |
| Alkalinity | mg/l | 00410 | X | | | |
| Chlorides | mg/l | 00940 | X | | | |
| Sulfates | mg/l | 00946 | X | | | |

# Appendix I
# Dissolved Metals – Clean Field Sampling Protocol

# Dissolved Metals – Clean Field Sampling Protocol

The purpose of this section is to present the standard operating procedures for collection and processing of water samples for determination of dissolved metals. Dissolved metals are those metals that pass through a 0.45 μm pore size capsule filter. Capsule filters are disposable, self-contained units composed of a pleated filter medium encased in a plastic housing that can be connected in-line to a sample-delivery system (peristaltic pump) that generates sufficient pressure to force water through the filter.

The specific procedures include:

1. Office Preparations and Cleaning of Equipment;
2. Field Rinsing of Equipment Prior to Sampling;
3. Sample Processing and Preservation; and
4. Quality Assurance

## I. Office Procedures and Cleaning of Equipment

Requisite Supplies

1. Ultra pure deionized water (UPDIW); UPDIW may be stored in a pre-cleaned HDPE (high density polyethelene) container.
2. Concentrated, trace-metal free (HCl) acid. Aliquots must be diluted with UPDIW to 5% and stored in a non-contaminating container.
3. Assorted safety-labeled wash bottles for UPDIW and dilute acid.
4. Liquid detergent (Liquinox) that does not contain either phosphates or NTA.
5. Disposable, non-powdered vinyl gloves.
6. Non-contaminating, non-metallic, clear/uncolored polypropylene/high density polyethylene basins.
7. Ziplock bags

Cleaning Procedure

Follow procedure in STEP 6 with following modifications:

1. Place ends of silicone tubing in wash basins. Run mid-section of tubing through peristaltic pump. Soak for thirty minutes by turning on pump and circulating wash solutions through tubing.
2. Double bag cleaned tubing and bottles.
3. After bottles are cleaned, fill with small amount of DIW to be discarded at time of sampling.

## II. Field Rinsing of Equipment Prior to Sampling

Field rinsing is required to ensure that all cleaning solution residues are removed and to equilibrate the sampling equipment to the sampling environment.

Requisite Supplies

1. Disposable, non-powdered vinyl gloves.

Procedure

1. Put on pair of disposable gloves.
2. Collect sufficient quantities of stream water following procedures listed for wading or bridge sampling in STEP 9.

## III. Sample Processing and Preservation

As noted in the opening, the definition of a dissolved constituent is an operational definition based on filtration through a 0.45 μm membrane filter. Trace metals will be processed through a 0.45 μm capsule filter. Processing and preservation protocols utilize the "Clean"/"Dirty" hands protocol. Ideally two individuals should perform this protocol.; however, the protocol can be performed by a single individual. Powder-free gloves are required in both the processing and preservation steps. If a single person is performing the sample collection from a bridge, multiple glove changes will be required. Gloves must be changed each time they are contaminated. Gloves are considered contaminated whenever they come in contact with any material other than the sample bottles and caps.

Requisite Supplies

1. Deionized water
2. Disposable non-powdered vinyl gloves.
3. Capsule filters.
4. Peristaltic pump and pump tubing (the peristaltic pump used by the Division of Water is powered off the vehicle battery) (silicon tubing size is 0.1924 in. [inner diameter] X 0.3915 in. [outer width] and 3 ft. in length).
5. Pre-cleaned sample bottle and weighted bottle sampler (if sampling non-wadeable stream).
6. Processing/preservation chamber (design described in STEP 11).
7. New capsule filters and silicon tubing are required for each new sampling site.

Procedure

1. Collect the whole-water sample, using the appropriate sampling procedure as presented in STEP 9 for site and flow conditions. It is important to remain cognizant of potential sources of contamination when sampling, limiting

sources of contamination. When sampling from metallic structures, it may be useful to spread a large plastic sheet over the area where sampling is to take place. If the sampler makes contact with a potential contaminant, dispose of gloves and put on a new pair. Try to time sampling to periods of low traffic flow. When sampling is completed, return to vehicle for sample processing. If bridge sampling, disassemble traffic work zone set up and drive to nearby off-road parking site.

2. Park the field vehicle away from highway and turn motor off. Road dust and emissions from vehicles can contaminate trace metal samples for microgram-per-liter analysis. The open door from the vehicle should face away from the highway. Put on disposable gloves.
3. Set up processing/preservation chamber; set up peristaltic pump with tubing; make two small holes in side of chamber and run ends of tubing into chamber. Change gloves. Attach capsule filter to one end of the tubing.
4. Inside of chamber place HDPE container containing UPDIW; also place a container for "waste" UPDIW, bottle containing sample and 500 mL bottle to receive filtered sample.
5. Pass 500 mL of UPDIW through the pump tubing and through capsule filter. After passage of the UPDIW, remove the tubing from the UPDIW reservoir and continue to run the pump to drain as much of the fluid remaining in the system as possible. Shaking the capsule filter may facilitate removal of the entrained water. Discard all the fluid.
6. Transfer the pump tubing to the bottle containing sample.
7. Start up peristaltic pump and filter about 50 mL of sample water into waste container.
8. Transfer capsule filter over the sample bottle opening and filter about 25 mL into bottle. Cap and shake bottle to rinse. Pour into waste container.
9. Process the filtered trace metal sample by filling the rinsed bottle.
10. Once filtration is completed, add 0.5 mL of $HNO_3$ to bottle.
11. Place filtered sample into sealable bag and place on ice in cooler.
12. Disassemble processing/preservation chamber.

**Quality Control Procedures for Dissolved Metals**

Field collected quality control samples are required for evaluating the quality of the sampling and processing procedures as well as for the actual data. Without quality control data, the sample data cannot be adequately interpreted because errors associated with the sample data are unknown. Quality control in the overall monitoring program is presented in Appendix F.